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THE UNIVERSITY OF ALBERTA

PART-WHOLE TRANSFER OF A COMPLEX  
PERCEPTUAL MOTOR TASK

by



REX HERBERT BEACH

A THESIS

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UNIVERSITY OF ALBERTA  
FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "PART-WHOLE TRANSFER OF A COMPLEX PERCEPTUAL MOTOR TASK", submitted by REX HERBERT BEACH in partial fulfilment of the requirements for the degree of Master of Arts.



## ABSTRACT

The purpose of this study was to investigate whether practice on sub-tasks of a complex perceptual-motor task were beneficial. In addition, the economy of learning sub-tasks was compared to whole task training. The sub-tasks of pivot and chest pass were compared to determine if both contributed equally to learning of the whole task.

Ninety boys from five elementary schools participated in the study. They were randomly assigned to groups and tasks. Three groups (N=30) were formed. Two experimental groups performed either the pivot sub-task or the chest pass sub-task before practice on the whole. The third group was designated as control and only trained on the whole task.

Both experimental groups benefited from sub-task training. The accrued benefits varied according to the type of sub-task training. It was found that training on the pivot sub-task was significantly more beneficial than training on the pass sub-task. Sub-task training benefits were affected during whole task training by the interfering effects of integrating unlearned parts.

Conditions of positive, negative, and zero transfer effect were noted. It was also found that learning the whole complex perceptual-motor task for all three groups was related to errors.

In terms of economy the most efficient method of learning was by whole task training without including preliminary practice on a subordinate skill.



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## CHAPTER I

### STATEMENT OF THE PROBLEM

Introduction. Teachers and learning theorists are continually looking for methods of improving the speed and efficiency of learning a perceptual-motor task. It might be helpful, for the purpose of improving performance, to separate a complex motor task into its sub-tasks and allow practice in each one separately. Whether practice on a sub-task of a complex skill is beneficial or not involves investigation of transfer effect.

Practice of a sub-task may facilitate (positive transfer), impede (negative transfer), or causes changes which are not measurable (zero transfer) in performance of the whole. Investigation of transfer effect can be of value in determining the economy of teaching sub-tasks. Economy of learning can be assessed in relation to trials to reach a desired level of learning; reduction of errors; increase in speed or rate of learning; or improvement of accuracy. If a complex perceptual-motor skill has more than one sub-task, it would be of interest to find out whether training on one sub-task contributes a greater degree to the learning of the total than training on others.

In a study by Gagne and Foster (52:47) significant levels of positive transfer from sub-tasks to the whole were found. The experiment involved a complex task which required four differential manual responses to four lights. Responses to two lights and two switches in different combinations constituted sub-task training. Results showed



that practice of a sub-task facilitated the acquisition of the whole. However, in terms of learning economy none of the amounts of preliminary practice accomplished as much learning as the same amount of practice on the total skill. The investigators (52:47) did not find any significant evidence to show that either of the two sub-tasks was more facilitating than the other. They did note that groups having either thirty or fifty trials of pre-training committed fewer errors (pressing wrong switches) than the control group. One pre-training group, which received only ten trials of part-practice, was found to commit more errors than the control group. In addition, the ten trial pre-training group did not show a significant positive transfer effect to the whole. Further analysis of error results revealed that the thirty and fifty trial experimental groups made fewer errors on the lights and positions that made up a part of their sub-task training. In a similar experiment to the one cited above, Gagne and Foster (51:342) also found evidence of positive transfer and reduced error scores on sub-tasks previously practiced. Analysis of a group (51:342) that practiced a pictured representation of the whole task showed that a training situation which represents the whole, even in pictured form, has a greater effectiveness than the same amount of training on a part of the actual task.

Bilodeau (16:5087) conducted three experiments on transfer of training on a two-hand tracking device. Transfer effects for various types of part practice were evaluated; using one hand exclusively, alternating between right and left hands in one-hand practice and two hands used in passive practice (following the crank movement of another tracker). Results from all three studies showed positive transfer from sub-task practice to the whole. Others (65,85,16) have also found evidence of positive transfer from sub-task training to the whole.



Positive transfer has been found by several investigators (55,15, 24,7) from practice of verbal tasks to a perceptual-motor task. Most of these studies involve giving verbal responses to the position of a lever or some other device which is later moved manually.

The effect of transfer on selected gross motor tasks has been studied by a number of researchers (24,71,31,33,90,91) in a variety of experiments. Lundeburg (71:180) concluded that transfer is highly specific when he noted that training in table tennis or special arm exercises didn't facilitate coordination efficiency in finger pressing or peg-shifting tasks. Cratty (33:523) investigated transfer of small-pattern maze practice to a larger identical pattern maze. Various conditions of prior practice were used and results showed that prior reverse small-pattern practice of the larger maze caused initial negative transfer to the larger pattern. It was also found that prior similar small-pattern practice caused initial positive transfer to the larger pattern. Nelson (90:374) studied the transfer effect of swimming on the learning and performance of two complex gross motor skills. He found that learning the swimming skills did not impede or facilitate the learning and performance of gross motor skills with dissimilar patterns and movements. Nelson conducted another transfer experiment (91:364) using six skills that were paired for study. He wanted to see if the badminton volley would facilitate tennis stroking; if the volleyball tap would assist the basketball tip; and if the track start would facilitate the football stance start. Results indicated some positive transfer but results failed to attain statistical significance.

Studies by several investigators (6,8,39,56,84) show that transfer effect increases as tasks become more similar. Muckler and Matheny (84:364) did a study on the transfer effect in tracking as a function



of control friction. Seven groups practiced tracking under different control friction pressures ranging from zero to twelve pounds. A control group practiced sine wave tracking at six pounds pressure and repeated the final tracking task at the same pressure. The control group, who had preliminary practice at six pounds of friction, achieved one hundred per cent transfer to the final task. The experimental groups attained transfer scores ranging from eighty-six to ninety-three per cent transfer. The data showed that where control forces are variable, optimum transfer will be obtained by exact simulation. It was also shown that the closer the practice friction was to the final task the greater the transfer.

Results of research by several investigators (16,45,51,52,65,85) show evidence of positive transfer from parts of a complex task to the whole. The studies reveal that learning sub-tasks facilitates the acquisition of the whole. All these studies involve fine perceptual-motor tasks using the hands. From a practical view these studies do not reveal any trend to indicate that learning sub-tasks is superior to learning the whole. Studies by Gagne and Foster (51:49), revealed some evidence of error reduction on parts of the complex task which had been previously practiced as a sub-task. There is little evidence in the studies previously cited (16,45,51,52,65,85) to show whether one sub-task contributed more to the learning of the whole than training on others.

Study of related literature on part-whole transfer supports the hypothesis that learning a part of a complex perceptual-motor task will facilitate the acquisition of the whole, yielding positive transfer effects. The literature also supports the premise that learning the whole task is as economical as learning parts, then the whole.

The Problem. The purpose of this study is to investigate whether



practice on sub-tasks of a complex perceptual-motor task are beneficial. The complex perceptual-motor task in this study is a one hundred and eighty degree pivot right or left by a subject followed by the chest passing of a basketball through one of two basketball hoops situated to the right and left of the subject (see fig. 1).

Two sub-tasks are identified for purposes of study. One is the pivoting movement right or left and the other is the chest passing movement.

#### Sub-Problems.

1. To determine if there is any learning economy doing sub-tasks before the complex perceptual-motor task. Learning economy will be evaluated in terms of performance time, number of trials, and errors.
2. To determine whether training on one sub-task (pivoting) contributes more or less to the learning of the whole than training on the other sub-task (chest passing).

#### Limitations.

1. This study is limited to ninety, ten year old males registered in the Edmonton Public School Board.

#### Definition of Terms.

1. Chest Pass Sub-Task: a part of the whole complex perceptual-motor task and is fundamentally the same movement as a basketball chest pass.
2. Complex Perceptual-Motor Task: integration of various sensory perceptual factors and the multiple involvement of arms, hands, fingers, and legs.
3. CP-W: an abbreviation for the electronic time score; chest pass time on the whole task. The score is a computation in which total performance time for the pivot sub-task is sub-



tracted from total performance time for the whole complex perceptual-motor task.

4. Fine Motor Task: involves movements of the body's segments through space, while the body's center of gravity remains fixed. A fine motor task may involve arm and leg movement, exclusive of, or accompanied by, hand-finger manipulation. The larger muscles of the body generally act as stabilizers during the performance of such a task.
5. Gross Motor Task: involves movement of the entire body through space, through large muscle activity. The body's center of gravity changes position through locomotion. It may be accompanied by fine adjustments of the head and/or the extremities.
6. Movement Time: the elapsed time between the onset of the stimulus and the completion of the response.
7. MT1: an abbreviation for the electronic time score; movement time one. MT1 represents the total time required to perform the pivot sub-task.
8. MT2: an abbreviation for the electronic time score; movement time two. MT2 represents the total time required to perform the whole complex perceptual-motor task.
9. Pivot-Sub-Task: a part of the whole complex perceptual-motor task and is a movement similar to a basketball pivot.
10. PMT: an abbreviation for the electronic time score; pivot movement time. The score is a computation in which reaction time for the pivot sub-task is subtracted from the total performance time for the pivot sub-task.
11. Reaction Time: the time lag or latency period between a



stimulus and its overt response.

12. RT1: an abbreviation for the electronic time score: reaction time. RT1 represents the latency period between the lighting of an "action" light for pivot and the overt response of pivoting.
13. Total Movement Time: the total time elapsed between the onset of the initial visual stimulus and the completion of the whole task. This period of time is made up of reaction and movement times.
14. Transfer: the carrying over of an act or way of acting from one performance to another.
15. Transfer Effect: the action that practicing one activity or task has upon the subsequent performance of another task. The effect may be beneficial or facilitating, detrimental or interfering, or have no measurable effect on the second.
16. Visual Stimulus: refers to the visual signal to which a subject reacts. These visual signals are in the form of a bright neon light and may also be referred to as "action lights".
17. Whole Task: refers to the total complex perceptual-motor task which has two sub-tasks; pivoting and chest passing.



## CHAPTER II

### RELATED LITERATURE

Part-Whole Transfer Studies. A number of experiments on transfer of training (16,45,51,52,65,85) have provided evidence concerning the relation between practice on components of a task and degree of transfer to the final task.

In a study of transfer in which subjects practised components of a motor skill, Gagne and Foster (52:47) obtained results which showed a significant level of positive transfer from parts of a task to the whole. In this experiment, five matched groups of thirty subjects learned a complex task which involved four differential manual responses to four lights. Part training on the discriminations of reaction to upper and lower positions of two lights was given to three different groups for ten, thirty, and fifty trials. A fourth experimental group received part training for thirty trials on the discrimination of responses to the color of the lights instead of their position on the apparatus.

Following preliminary training, the experimental groups practiced the total skill for sixty trials. The total skill involved color and position discrimination using four switches and four lights. A control group was given eighty trials on the total skill without any preliminary practice. The learning of the skill was measured in terms of time required for each correct reaction and number of errors.

Significant positive transfer for the experimental groups receiving thirty and fifty trials of training on part of the total skill



was evidenced. This transfer exerted its effect, according to the results, through trials forty to fifty of the total motor skill. The experimenters also observed that in spite of the positive transfer effect for three experimental groups, none of the amounts of preliminary practice given in the experiment accomplished as much learning as the same amounts of training on the total skill. Errors made pressing the wrong switches were also recorded. It was noted that those having thirty or fifty trials of part practice made fewer errors than the control group on the whole task. They also found that the amount of transfer to the whole did not vary significantly when different tasks were employed.

The experimental group that had only ten trials of part practice didn't show any significant evidence of positive transfer to the whole. It was also found that the ten trial experimental group made more errors than the control group on the total task.

The results of Gagne and Baker's work were supported by another study (45:314) using the same subordinate and total tasks. In this study (45:314) three groups of fifty navy men were used. A control group practised the total task which required the subject to hit one of four switches on a horizontal panel in response to one of four lights appearing on a vertical stimulus panel. They received sixty trials. One experimental group received thirty trials of part-task practise on color discrimination followed by sixty trials of practise on the whole task. A third group was assigned position discrimination as a sub-task and received thirty trials of part practise followed by sixty trials of practise on the whole task.

Gagne and Foster (45:314) stated:

Thirty trials of preliminary training on either color discrimination or position discrimination resulted in considerable positive transfer to the final motor task involving both types of discrimination. Both the experimental groups had



significantly shorter response times than those of the control group throughout sixty trials, although the reduction is particularly pronounced in the initial stages of learning.

Gagne and Foster (51:342) studied the transfer effect of practising a pictured representation of the task followed by practice on the actual task. Five matched groups of men were given varying amounts of practice on a paper-and-pencil test which represented the apparatus. All groups received sixty trials on the whole task. The apparatus and tasks were the same as that used in previous experiments (52:47, 45;314). Significant transfer scores were obtained for all experimental groups over the control at different trial stages beyond trial twenty. Groups who had eight or sixteen trials on the pictured representation also had scores on the final task that were significantly better than the control group. In a previous study (52:47) the experimental group with ten trials of part practice had inferior scores to the control group on the whole task. From this comparison, Gagne and Foster (51:342) implied that a training situation which represents the whole task, even in pictured form, has a greater effectiveness than the same amount of training on a part of the actual motor task.

Jones and Bilodeau (65:2221) reported a study in which subjects performed a two-hand tracking task in which they controlled a movable pointer in two dimensions by turning cranks. They reported that transfer from a complex ("clover leaf") tracking task to a simple (circular) tracking task was greater than transfer from the simple to complex.

Bilodeau (16:5087) conducted a part-whole transfer of training study on a two-hand tracking device. Part practice with one hand exclusively; alternating between right and left hand in one-hand practice; and two hands used in passive practice (following the crank movement of another tracker), were evaluated for transfer effect. The results in-



licated a positive transfer effect to the whole task of tracking with two hands.

Mukjejee (85:215) used a modified version of the Two-Hand Coordination Test to study the relationship between the level of initial scores and transfer of training on its simple part to its complex part. The task was tracking along a path which included a simple part and a complex. The simple part required input proportion of just fifty per cent with each hand while the complex part required cranking input of varying magnitudes and handle movement in different directions by both hands. Performance was recorded in time taken to transverse the tracking pattern which was twenty-five centimeters long. Errors were also scored when the tracking pin hit the sides of the tracking path. Forty-six "normal" youths were pre-tested on the whole task and from these initial scores divided into four groups of ability with half the subjects in each group acting as controls. The experimental groups received one hundred practice trials on the simple part which the controls did not get. Then the groups, both experimental and control, practised for one hundred trials on the complex part.

From the results (85:215) it was observed that the four experimental groups had better learning efficiency than their corresponding control groups on the complex part of the task. It was found that as initial performance level increased, the amount of transfer from the simple to complex part also increased.

The studies of Batson (13:91), Smith (106:1) and Kao (68:219) were concerned with the integration of components in complex motor skills. The task in Smith's study was one of tossing a ball alternately with the left and right hands to hit left and right hand targets on a wall with



a force which would make the ball bounce to a target on the floor. The subjects in this experiment practiced various components of the total task before attempting to perform the whole activity. The components were fairly similar to each other, and some evidence of interference was obtained when two or more of them were put together. Interference usually occurred at the stage when new, unpracticed components were added to the task to be performed alternately or successively with old and more practiced components. Kao, (68:219) in one experiment, used a total task which required the subject to hit a swinging pendulum. The subjects practiced separately the components of aiming in a particular direction, at a particular time, and with a given force before attempting to learn the total skill which involved the integration of all three components. In another experiment this author studied the acquisition of the skill of throwing, into a target, shot picked up from a board with tongs. Again the subjects practiced the components of this skill separately and later attempted to perform the total skill. In general, Kao's results indicate that plateaus occur in the case of these skills only when the subjects attend to the part processes separately. The results may be interpreted to mean that not all complex skills are subject to the occurrence of plateaus during the course of their acquisition.

Lewis (69:423) investigated transfer using a three-part motor task. Practice could be given on any one of the three parts separately, or on any two of them in combination, or on all three together. One part practice resulted, during test trials, in inferior performance on the complex task, but complex performance following two part practice did not suffer by comparison with performance following whole practice throughout.



Transfer Studies Involving Gross Motor Tasks. Lindeburg (71:180) investigated the transfer effects of quickening exercise on three different coordinated muscular movements in a study involving forty-seven subjects. Four groups of subjects were pre-tested on simple finger press, normal peg-shifting, and a modified peg-shifting task. After the pre-test, three experimental groups took a regular P.E. program or a regular P.E. program plus special arm exercises, or table tennis. The control group did not engage in any activity program. All groups were given a post-test on the finger press and peg-shifting tasks. Results didn't show positive transfer of training from the activities of table tennis, regular P.E., or special arm exercises to coordination efficiency in the finger press, normal peg-shifting, or modified peg-shifting, as measured by the speed of movement. The results, state Lindeburg (71:180), "agree with the theory that transfer is highly specific and occurs only when the practice movements are identical."

Cratty (33:523) used mazes of different sizes to determine whether transfer occurred between the learning of two similar spatial patterns; one thirty times larger than the other. Specifically, Cratty wanted to assess whether prior practice on various small spatial patterns would impede or facilitate the learning of a task involving larger movements. Sixty subjects were randomly assigned to four groups. One group had twelve spaced trials on a stylus maze containing a pattern similar to that of a large locomotor maze. Another group had twelve trials on a mirror reversal of the larger maze. A third group had twelve spaced trials on a maze whose pattern was unrelated to that of the larger maze. The control group had twelve trials on the larger maze without prior practice on any other maze. Subjects learned all mazes blindfolded and learning criterion was traversal



time. Results showed that prior reverse small-pattern practice of the larger maze caused initial negative transfer to the larger pattern. It was also found that prior similar small-pattern practice caused initial positive transfer to the larger pattern.

Nelson (90:374) studied the transfer effect of swimming on the learning and performance of two complex gross motor skills. Forty college men were matched on the basis of a pre-test and placed into an experimental and a control group. The experimental group learned the two selected skills in addition to swimming, whereas the control group learned only the selected skills. Results showed that the learning of swimming skills does not impede or facilitate the learning and performance of gross motor skills with dissimilar patterns and movements.

In another experiment by Nelson (91:364) six skills were selected and paired for study. Badminton volley was paired with tennis stroking to see if practicing one would facilitate the learning of the other. Volleyball tap and basketball tap for accuracy were also paired. The track start was taught and its effect on the football stance start analysed. Most of the results did not attain statistical significance, but Nelson indicated that some facilitation occurred for the tennis skill to badminton skill, from the basketball skill to the volleyball skill and from the track start to the football stance start.

Similarity of Tasks and Transfer Effect. Baker and Gagne (6:721) conducted an experiment which dealt with transfer of training as a function of difference in response rate between training and final tasks. The task employed in the study involved turning a crank so as to keep a pointer in alignment with a target which moved irregularly back and forth over a one hundred and twenty degree sector on the circumference of a dial. Four



rates were used. Five matched groups of thirty-one male subjects were given eight trials at one rate followed by eight trials at another rate. Findings showed a significant degree of positive training from the training rates to the final task rate and that the relative amount of positive transfer obtained from training depended on the degree of similarity between the training and final tasks.

In another study, Baker and Gagne (8:465) examined transfer effect and stimulus similarity using response to colored lights as the task. As in the study cited above (6:721) results showed that transfer decreased with increasing dissimilarity of stimuli.

Duncan (39:10) studied transfer between two tasks as a function of degree of learning of the first task and similarity of tasks. The subjects were required to associate each of six colored-light stimuli with movements of a lever, grasped by the right hand, into six radially arranged slots. There were three degrees of inter-task similarity arranged as a twelve cell factorial design in which three hundred subjects were used. Similarity between tasks was defined in terms of the number of lights newly paired with different slots in the final task. Results showed that transfer was positive for all experimental groups whether measured in terms of correct responses or errors. Further, transfer increased directly with inter-task similarity.

Greenspoon and Anderson (56:201) examined the effects of stimulus similarity and delay on transfer to a visual-motor task. The subjects were trained on the same stimulus value and then retrained on the same or different stimulus values after different intervals of time. Results showed that the greatest amount of transfer occurred on stimulus values that were closest to the stimulus value of the original training. Moreover, longer time intervals between original learning and test of transfer tended to produce the greater amount of transfer. The transfer effect was found to be limited



with control groups performing as well as the experimental groups in a relatively small number of trials.

Rockway (99:44) designed a study to investigate the relationship between amount of transfer of a tracking skill and the degree of similarity between training and the control-display ratios. The findings indicate that the more similar the training and control-display ratios, the greater the transfer.

Woodward (116:12) conducted a study in which an experimental group and a control group of trade school girls, equated for I.Q., age, trade training, and trade rating, were given an initial and a final group of trials at assembling a simple loom. For the experimental subjects there was interpolated training in assembling a safety switch, a task which made use of different materials but involved the same general pattern of motions and total work situation and nearly the same specific motions as those involved in assembling the loom. Some transfer of training occurred for the experimental group, states Woodward (116:12) and is "probably due to the great similarity of the two assemblies."

Muckler and Matheny (84:364) studied the transfer effect in tracking as a function of control friction. One hundred and five subjects were randomly assigned to seven groups who performed the tracking task under zero, two, four, six, eight, ten, or twelve pounds of pressure. The six pound pressure group was selected as the control group. All groups received twenty sine wave cycles of preliminary practice followed by practice on the final task (six pounds of friction) until a learning criterion had been met. Analysis of scores showed high percentages of transfer for all groups. The control group, who had preliminary practice at six pounds of friction, achieved one hundred per cent transfer to the final task which was also done at six pounds of pressure. The other groups achieved transfer scores ranging from



eighty-six to ninety-three per cent transfer. The data showed that where control forces are variable, optimum transfer will be obtained by exact simulation, however, little was lost if the control force varied. It was also shown that the closer the practice friction was to the final task the greater the transfer.

Task Difficulty and Transfer Effect. Barch (9:37) investigated the kind and amount of transfer in a two-hand coordination experiment where two tasks were complete reversals of each other and task difficulty was varied by changes in target size. Five groups of fourteen female college students served as subjects. All groups had thirty trials on the training task which required manipulation of two handles so as to keep a small button on top of a target which moved in an irregular pattern. Movement control with the two handles was reversed for three groups on the final task. The remaining two groups received final task training on controls in which only one of the two handles had been reversed. Training task difficulty was varied using small, medium, or large targets. All groups had training on the final task using the small-sized target. Analysis of final task scores showed that transfer was greatest for those groups practicing on the small-sized target (most difficult) followed by practice on the final task with the small target (difficult).

Lordahl and Archer (72:426) used a rotary pursuit task to study transfer effects as a function of first task difficulty. Task difficulty was varied using speed of target rotation and radius of the target orbit. After ninety subjects had been tested in six different task situations varying in difficulty, it was found that the speed variable produced significant differential transfer effects. These effects lasted for several trials. The control groups, whose preliminary task was identical to the final task, performed better than the experimental group.



Namikas and Archer (88:109) also studied transfer effect and task difficulty using the pursuit rotor. Speed of rotation was varied for groups. One hundred and twenty subjects were given twenty training and twenty transfer trials. Results showed that performance was better at slower speeds and transferring to the same speed gave the best performance.

Holding (63:397) reported two experiments, both of which involved tracking on a simulated radar scanner by manipulating a control stick mounted on the arm of a chair. Sine wave frequency could be varied to get random target courses. Holding said:

The first experiment explores an absolute difficulty hypothesis to the effect that transfer might be greater from a point of optimum difficulty, whether to an easier or to a more difficult task; changes in difficulty were achieved by controlled variation of the complication of pursuit tracking courses. However, after a week's practice on the twelve task conditions, it appeared that transfer was consistently most effective in the difficult-easy direction.

In a second experiment, subjects were transferred between tasks with easy and difficult course amplitudes, at both easy and difficult levels of complication. In this case, the easy-difficult order of practice was better with the simpler courses, while the complex courses favoured difficult-to-easy transfer. It is concluded that difficulty is not a useful category for the predication of transfer efficiency, and that the solution lies in examining the skills involved. Explanations are outlined in terms of inclusion and error size constance, although it is probable that many other factors play a part.

Szafran and Welford (109:88) also studied transfer effects and difficulty of initial task. In their study, six groups of fourteen subjects each were required to throw light pieces of chain at a target under three conditions of difficulty. In the simpler of the three tasks, the target was placed flat on the floor and eight feet from the subject. The second task was the same as the preceding task except the subject had to throw over a horizontal bar. The third condition was rated as most difficult because a screen hid the target and could only be seen via a mirror. They concluded that transfer tended to be positive from a relatively difficult



initial task to an easier one and negative for a relatively easy to a difficult one.

A study by Rivenes (97:485) was devised which enabled subjects to practice one or more tasks varying in degree of difficulty on a distance dimension. A series of six novel tasks resembling modified shuffleboard skills were administered to nine groups of male students at the Pennsylvania State University. Analysis of results revealed that multiple-task practice of relatively easy practice tasks increased transfer, whereas single-task practice of relatively difficult tasks was most advantageous. The amount of transfer expected from practice of relatively easy tasks did not combine in a linear summation with the amount of transfer expected from practice of relatively difficult tasks.

The results of most available research on task difficulty and transfer were neither confirmed nor challenged because of the uniqueness of the tasks, or they were in conflict with the results of experimentation with similar tasks. No valid overall pattern emerged from the available research and there was an almost complete absence of such research using sports skills.

Transfer of Verbal Training to a Motor Task. Several investigators (53,55,24,7,15) have examined the transfer effect of verbal pre-training upon acquisition of motor skills. All these investigators have found a positive transfer effect from verbal pre-training to the motor task.

Goss and Greenfield (55:258) had an experiment in which four white lights of different intensities served as stimuli for different verbal responses. Forty-eight experimental groups were given experience in seeing, discriminating, and naming the stimuli either overtly or covertly, seeing and discriminating, or seeing. All subjects then had seventy-two trials to move a lever in a different direction for each intensity. It was found that



all types of acquisition of discriminative verbal responses resulted in some positive transfer with the exception of the seeing response. The amount of positive transfer increased with mastery of verbal responses but did not vary with amount of seeing and discriminating.

The effect of complexity of a motor task was studied by Battig (15:371) in a finger-positioning task. He concluded that the amount of positive transfer from verbal pre-training to motor performance showed a consistent decrease as motor complexity increased in terms of number of fingers used on a finger-positioning task.

In a study by Cantor (24:180) three different amounts of verbal pre-training upon performance of a perceptual-motor task was investigated. In a motor task provided by the Star Discrimeter, the subjects learned to move a wobble stick into channels corresponding to six colored lights consisting of red-yellow hues. Three groups received varied amounts of relevant pre-training, three groups received irrelevant verbal pre-training and a control group did not receive any pre-training prior to the motor task. All subjects received forty trials on the final Star Discrimeter task. Results obtained supported the prediction that all three amounts of relevant pre-training provided positive transfer to the motor task. It was also found that the performance of the combined relevant pre-training groups was reliably superior to that of the combined irrelevant groups.

Baker and Wylie (7:632) also investigated the transfer effects of varying amounts of verbal training upon the subsequent learning of a motor task. The motor task used in the experiment was a discrimination learning problem in which the subject learned to press one of four appropriate switches upon the appearance of a red or green stimulus light in either of two positions. Pre-training consisted of verbal expressions of the stimulus-response relationships of the final task. Time and errors were used to measure



learning and results showed that eight trials of verbal pre-training yielded insignificant amounts of transfer. However, twenty-four verbal training trials did yield a significant amount of positive transfer to the performance of the motor task.

TABLE I  
SUMMARY OF PART-WHOLE TRANSFER  
STUDIES

Researcher	Task	Findings
1. Gagne, Foster and Boken (42, 45,51)	Fine Motor-Manual Response to 4 lights.	.Positive Transfer-Parts to Whole .Learning Whole Task More Economical .Amount of transfer to whole between sub-tasks did not vary significantly.
2. Bilodeau (16)	Fine Motor-Two Hand Tracking Device	.Positive Transfer-Parts to Whole
3. Mukjejee (85)	Fine Motor-Modified Two-Hand Coordination Test	.Positive Transfer .Learning Efficiency of Experimental Groups better than Control
4. Batson, Smith, Kao (13,106, 68)	Gross Motor-Ball Tossing at Targets, Hit swinging Pendulum	.Evidence of Interference noted when putting components of task together
5. Lewis (69)	Fine Motor-Three-Part Motor Task	.One Part Practice Inferior .Two Part Practice compared with Whole Practice



## CHAPTER III

### METHODS AND PROCEDURE

Description of the Test. The complex perceptual-motor task in this study was a one hundred and eighty degree pivot right or left, followed by the chest passing of a regulation basketball through one of two basketball hoops situated to the right and left of the subject. (see Figures 1, II, & III).

Two sub-tasks were identified for purposes of study. They were a pivoting movement right or left and a chest passing movement.

A pilot study was conducted using twenty-four boys. These ten year-old boys were randomly assigned to one of three groups (control, pivot sub-task, or pass sub-task) and then the three groups were randomly assigned to tasks (whole, pivot, or pass). Two boys were tested each day for twelve days with approximately two hours allotted for each subject's training session. The pilot study was used to standardize test procedures, check-out the electrical equipment, and determine the number of trials needed to bring subjects to a stable performance level on the complex perceptual-motor task and its sub-tasks.

Standardized instructions were given to the subject's in each of the three groups. One experimental group (N-30) was designated as the "pivot" sub-task group. They were given fifty trials on the pivot sub-task followed by fifty trials on the whole complex perceptual-motor task (See Appendix D for instructions to subjects). While this group practiced the pivot sub-task, the hoops and stimulus panel ("action" lights) used for the chest passing sub-task were covered (see Figure 4). After fifty trials



on the pivot sub-task and ten minutes rest, the experimenter removed the covers from the basketball hoops and stimulus panel ("action" lights for chest pass sub-task). Instructions were given to the pivot sub-task group for training on the whole.

This practice was followed by fifty trials of training on the complex perceptual-motor task (See Appendix D for instructions to pivot sub-task group for training on the whole task).

The second experimental group (N-30) was designated as the "chest" passing sub-task group. They were given fifty trials on the chest passing sub-task followed by fifty trials on the whole complex perceptual-motor task (See Appendix D for instructions to the subjects). During chest pass sub-task practice the stimulus panel ("action" lights) for the pivot sub-task were covered (see Figure 8). After fifty trials on the chest passing sub-task and ten minutes of rest, the experimenter removed the cover from the pivot sub-task stimulus panel ("action" lights) and gave instructions for practice on the whole complex perceptual-motor task (see Appendix D for detailed instructions). This practice was followed by fifty trials of training on the whole complex perceptual-motor task.

The control group was given seventy-five trials on the whole complex perceptual-motor task (see Appendix D for instructions to the subjects). Control group subjects were given a ten minute rest after the initial fifty trials of training.

The testing time for each subject in all groups was approximately seventy minutes. This training time was divided into two sessions with ten minutes of interpolated rest. During the interpolated rest the experimenter supplied each subject with liquid refreshment. Discussions during the rest period were always centered-away from the training sessions. Each subject had only one training session.





FIGURE I - Subject In "Ready"  
Position For Whole  
Task Training

FIGURE 2 - Subject Completing  
Pivot Sub-task

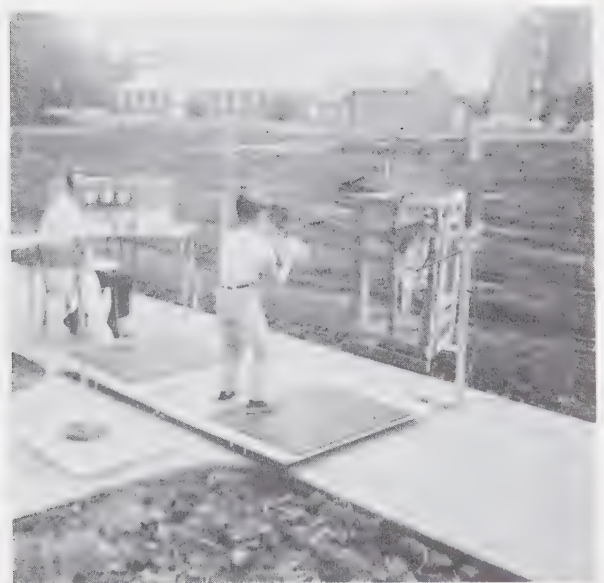






FIGURE 3 - Subject Completing  
Whole Task With  
Chest Pass Sub-task

A. Ball Breaking Contact  
Switch

FIGURE 4 - Pivot Sub-task Training;  
Subject in "Ready"  
Position

A. Chest Pass Sub-task  
Apparatus Covered





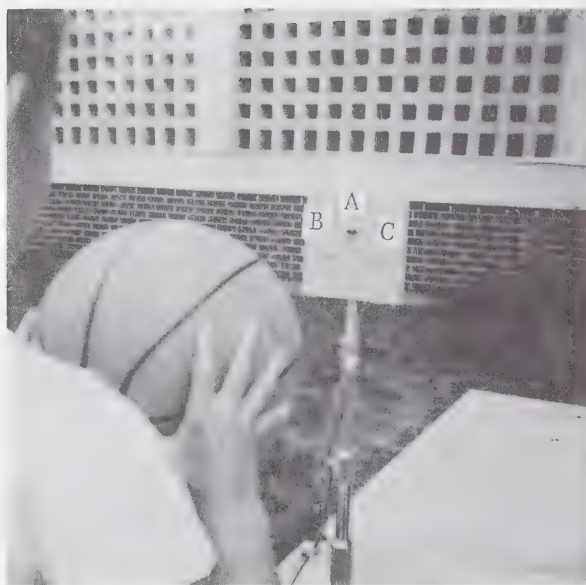


FIGURE 5 - Subject Completing  
Pivot Sub-task Training  
Trial

A. Right Foot On Contact  
Mat

FIGURE 6 - Stimulus ("Action")  
Lights For Pivot  
Sub-task

- A. Warning Light
- B. Left "Action" Light
- C. Right "Action" Light





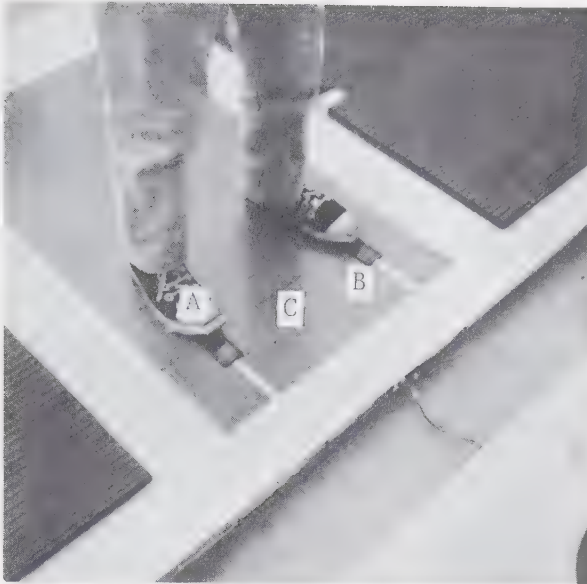


FIGURE 7 - "Ready" Position For Subject's Feet Prior To Performance Of Pivot Sub-task

- A. Magnets Taped To Subject's Running Shoes
- B. Reaction Time Impulse Coil
- C. Starting Line For Training

FIGURE 8 - Chest Pass Sub-task Training, Subject In "Ready" Position

- A. Pivot "Action" Lights Covered
- B. Stimulus ("Action") Lights For Chest Pass Sub-task





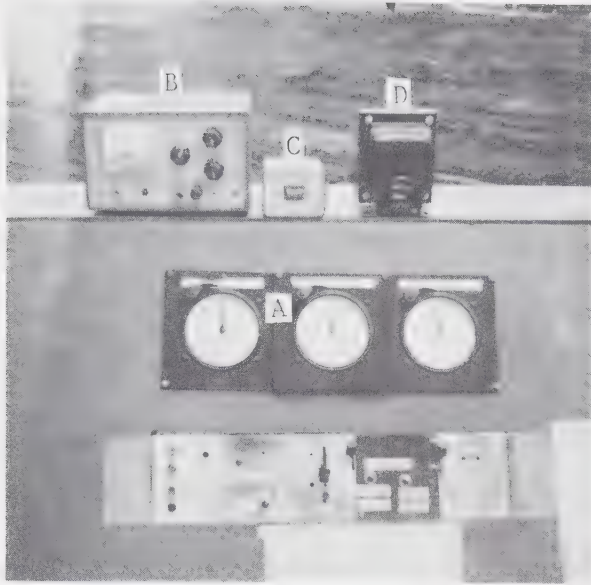
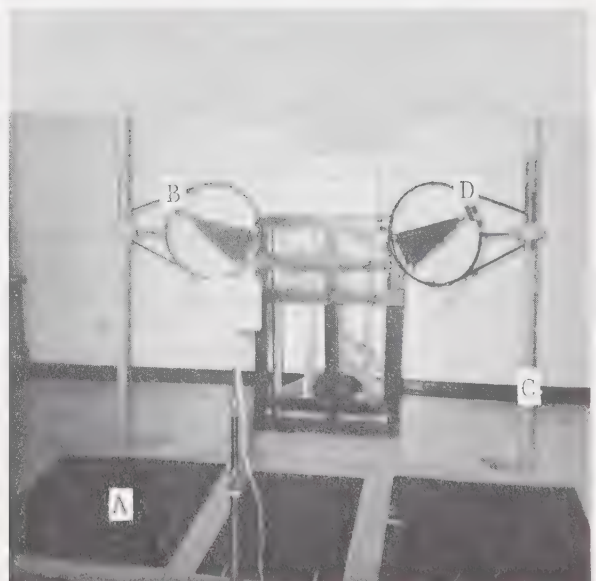


FIGURE 9 - Control Panel  
(Electronic Devices -  
A, B, & C, on top of  
Control Panel were  
situated within Panel  
during testing)

- A. Chronoscopes
- B. D.C. Power Supply
- C. D.C. Power Supply For Phil-  
brick Operational Amplifier
- D. Isolation Transformer

FIGURE 10 - Training Apparatus

- A. Contact Mats
- B. Adjustable Hoops
- C. Adjustable Stands For  
Hoops
- D. Contact Switch Assembly





Time scores for training trials were obtained from three Standard Electric Chronoscopes. The obtained measure for reaction time on the pivot sub-task was designated as RT1 in the study; a movement time score for the pivot sub-task was designated as MT1; a chest pass sub-task measure was designated as CP-S; and a measure for the whole complex perceptual-motor task was designated as MT2. Additional time measures were obtained by subtracting the pivot reaction time (RT1) from the pivot movement time (MT1) to get a pivot movement time minus the reaction time (RT1). This measure was designated in the study as PMT; another time measure was obtained by subtracting the total time for the whole task (MT2) from the movement time on the pivot sub-task (MT1) to get a relative measure of chest pass sub-task time. This measure was designated as CP-W.

The subjects in each group made certain errors in training which could not be detected electronically. These errors fell into four categories: pivoting the wrong way, hitting the rim of the hoop, passing through the wrong hoop, and incorrect chest pass technique.

Errors of this type were recorded on a Subjective Error Tally Sheet for each subject (see Appendix B).

Description of the Subjects. The subjects used in the experiment were one hundred and fourteen boys (ten years of age) selected from the Edmonton Public School Board System. From this total, twenty-four boys were involved in the pilot study. These volunteer subjects were obtained from the class lists of five different elementary schools. Letters were sent to the parents of subjects. The letter (see Appendix B for detail) outlined the experiment and requested consent.



TABLE II  
SUBJECTS FOR GROUPS AND THEIR AGES

Control Group			Pass Group-Experimental			Pivot Group-Experimental		
No.	Initials	Age Yrs/Mo.	No.	Initials	Age Yrs/Mo.	No.	Initials	Age Yrs/Mo.
1	B.B.	10-9	1	E.A.	10-5	1	J.B.	10-5
2	I.B.	10-8	2	N.B.	10-10	2	E.B.	10-8
3	D.B.	10-11	3	R.B.	10-6	3	M.B.	10-3
4	J.B.	10-1	4	M.B.	9-10	4	G.C.	10-1
5	D.B.	10-4	5	G.B.	10-4	5	J.D.	10-10
6	B.B.	10-11	6	S.B.	10-3	6	A.E.	11-0
7	L.C.	10-3	7	S.B.	10-1	7	J.F.	10-2
8	D.C.	10-4	8	D.C.	10-0	8	R.G.	10-6
9	B.C.	10-6	9	D.C.	10-10	9	H.G.	10-6
10	B.F.	10-9	10	G.C.	10-11	10	D.G.	10-3
11	R.H.	10-7	11	A.E.	10-7	11	G.G.	10-3
12	J.H.	10-3	12	D.F.	9-10	12	A.H.	10-4
13	N.H.	9-6	13	D.G.	10-6	13	N.H.	10-11
14	L.L.	11-0	14	M.H.	10-9	14	B.H.	10-1
15	J.M.	9-11	15	J.H.	10-0	15	J.H.	10-4
16	N.M.	10-2	16	C.J.	10-7	16	J.H.	10-7
17	M.M.	10-7	17	D.L.	10-5	17	W.J.	9-10
18	R.M.	9-11	18	C.M.	10-7	18	S.J.	10-1
19	S.M.	10-1	19	G.O.	10-3	19	B.K.	10-2
20	V.M.	10-5	20	E.R.	10-2	20	J.K.	10-8
21	J.M.	9-11	21	T.R.	10-1	21	P.M.	10-5
22	J.P.	10-8	22	B.R.	10-8	22	D.M.	10-0
23	R.P.	10-6	23	B.R.	10-3	23	J.M.	10-6
24	D.R.	10-8	24	J.R.	10-3	24	R.M.	10-4
25	D.R.	10-11	25	D.R.	10-6	25	R.P.	10-7
26	G.R.	10-3	26	B.S.	10-9	26	K.P.	10-4
27	B.S.	10-3	27	G.T.	10-10	27	C.R.	10-7
28	R.S.	10-8	28	S.U.	9-11	28	B.R.	10-5
29	K.W.	10-1	29	L.W.	10-3	29	M.S.	10-6
30	G.W.	9-9	30	H.Z.	10-9	30	N.T.	10-6
Total		319-7			314-10			321-1
Mean		10-7			10-5			10-7



Each subject was asked to wear running shoes and a white T-shirt. Long or short pants were acceptable. The boys were in grade five or six at their respective schools and were free from physical and mental defects.

Assignment of Subjects to Groups and Tasks. The subjects were randomly assigned to one of three groups and then the three groups were randomly assigned to tasks. It was assumed that a random assignment of subjects to groups and tasks gave comparability.

Experimental Design. The experimental paradigm consisted of three groups, two experimental and one control. Each of the three groups had thirty subjects.

The three groups were randomly assigned to one of the three tasks.

TABLE III  
EXPERIMENTAL PARADIGM

Event Order			
Exp. Group	Training Trials	Minutes of Interp. Rest	Test Trials (Whole)
I (Pivot)	50	10	50
II (Chest Pass)	50	10	50
III (Whole)	50	10	25



The number of learning trials for each of the two sub-tasks (pivot and pass) was set at fifty (pilot study results) with single trial performance times requiring up to two seconds with inter-trial intervals averaging about twenty-five seconds. Inter-trial intervals were used to read and re-set clocks and inform the subject of errors committed and/or comment on performance.

The number of training trials for the whole complex perceptual-motor task was set at fifty for the experimental groups and seventy-five for the control. Fatigue factors due to task repetition were noted during pilot study and forced the investigator to set the whole task training for the control group at 75 trials. Single trial performance on the whole task required up to three seconds with inter-trial intervals averaging about thirty seconds.

Four subjects were tested each day, six days a week, until all subjects had been tested. Subjects from different groups were tested daily on a rotating basis, whenever possible, so as to test one experimental (pivot sub-task), one control (whole task), then one experimental (chest pass sub-task).

All subjects were motivated by making each training session a hypothetical game-like situation. This type of motivation was also supplemented with knowledge of results and frequent praise.

The direction the subject would pivot (right or left) or pass (right or left) was randomly selected for sub-tasks and whole by coin toss (see Appendix C for detail).

All subjects were tested at the Fitness Research Unit, Faculty of Physical Education, University of Alberta, Edmonton.

Description of the Apparatus. The experimenter's part of the



test apparatus is shown in Figure 9. It consisted of a control panel which had three Standard Electric Chronoscopes (calibrated to 1/100 of a second) and a switch panel.

The subject's part of the apparatus is shown in Figure 10. It consisted of a panel of instant neon stimulus lights for the pivoting sub-task (see Figure for detail); a platform with two large rubber mats on the right and left (see Appendix C for construction detail); two adjustable basketball hoops on vertical posts; and a second panel of instant neon stimulus lights used for the Chest Pass Sub-task (see Appendix C for detailed schematics of test apparatus).

In operation, the experimenter would press a warning button one to four seconds before switching on the stimulus "action" lights, which were always pre-set for right or left according to trial order for direction schedule (see Appendix D for detail). All clocks started automatically when the stimulus lights were activated. One set of stimulus ("action") lights directed the subject to pivot right or left. (see Figure 6). A second set of stimulus "action" lights informed the subject to which basketball hoop he should direct his pass (see Figure 8 and note stimulus panel directly in front of subject). The subject would respond to the stimulus "action" lights by pivoting left or right as indicated, or by passing the ball through the right or left basketball hoop.

Pivoting on to a rubber contact mat on the platform would stop one of the clocks (see Figure 2 and note subject's right foot on rubber mat), while a second clock was stopped when the basketball passed through a hoop into a net (see Figure 3). The third clock was used to measure reaction time for the pivot task. When the subject's foot moved, the electromagnets attached to them produced a pulse in the coils (see Figure 7 for detail) and this pulse was amplified and applied to the GT02 (see



electrical schematic in Appendix C for detail). Turning it on pulled in a relay and stopped the reaction time clock. The clocks were read after each trial and the magnetic switch on the basketball hoop was put back into position (see Appendix C schematic detail on breaker switch for hoop). The apparatus was then ready for the next trial. If a clock failed to stop during a trial the subject was told to stop and the trial was repeated.

Statistical Treatment. Results obtained from electric chronoscopes were grouped into blocks of five trials and analyzed. Graphs using means and standard deviation were plotted. The means for groups were compared using "t" tests to see if training on sub-tasks was more or less beneficial than training on the whole complex perceptual-motor task.

Transfer effect of sub-task training was evaluated using "t" tests of means and transfer effect formula (after Gagne, Foster, and Crowley 47:97).

A subjective assessment of errors was plotted graphically and evaluated



## CHAPTER IV

### ANALYSIS

#### Results

Sub-task Training. The general effects of sub-task training on whole task performance are pictured in figures 11, 12, 13, 14 and 15.

In figure 11, the training effects of sub-task pass practice over 100 trials are plotted. Mean performance time and standard deviation are presented on the vertical axis and trials on the horizontal axis. The mean performance time for trials 1-5 was 4.545 seconds and 3.734 seconds for trials 45-50. The learning score (see Appendix A for formula) for sub-task chest pass (CP-S) training was a time decrease of .811 seconds for 50 trials. The whole task chest pass training time (CP-W) was 4.264 seconds for trial 1-5 and 3.069 seconds for whole task training trials 45-50. The learning score for whole task chest pass (CP-W) was a time decrease of 1.195 seconds. The learning score over 100 trials of training was a time decrease of 1.486 seconds. Mean performance times for chest pass training showed a gradual decrease with the exception of trials 51-55. Mean chest passing time increased .530 seconds in trials 51-55 over trials 46-50. The whole complex perceptual-motor task was introduced at trial 51 after a 10 minute interpolated rest. The standard deviation for chest passing performance was greater on the whole task than when performed as a sub-task at all trial levels except 66-75.

The effect of practice on reaction time (RT1) over 100 trials as



performed by the sub-task pivot group is displayed in figure 12. The reaction time learning score over 50 trials of sub-task pivot training was a time decrease of 1.030 seconds and .371 seconds over 50 trials of whole task training. The learning score over 100 trials of training was a time decrease of .882 seconds. Mean reaction time was slightly higher during whole task training except for trial levels 51-65. At these levels the mean reaction time was lower when compared with trials levels 1-15. Mean reaction time in whole task training never decreased to the level previously achieved in sub-task pivot training. The standard deviation of reaction time performance decreases noticeably from trials 1-15 after which little change is perceptible. Performance fluctuations occurred between blocks of 5 trials with the most notable variation occurring at trial level 51-55 after interpolated rest and introduction of the whole complex perceptual-motor task.

Figure 13 provides information on the effect of training on pivot movement time (PMT) over 100 trials as performed by the sub-task pivot group. The PMT learning score was a time decrease of .627 seconds over 50 trials of sub-task pivot training and .004 seconds over 50 trials of whole task training. The PMT learning score over 100 trials was a time decrease of .356 seconds. Performance fluctuations occurred between trial means during sub-task pivot training as time scores gradually decreased. PMT time scores during whole task training never decrease to the level achieved during sub-task training for trials 26-50.

The effect of practice on movement time on (MT2) over 100 trials as performed by the sub-task pivot group is presented in figure 14. The MT1 learning score for 50 trials of sub-task pivot training showed a time decrease of 1.721 seconds and decrease of .217 seconds for 50 trials of whole task training. The learning score over 100 trials showed a time



decrease of 1.273 seconds. Mean performance times for MT1 decreased gradually after initial rapid improvement in trials 1-15 of sub-task training. The gradual decrease of MT1 performance scores was interrupted by the introduction of whole task training. Mean MT1 increased .765 seconds from trials 46-50 to 51-55. Slight decreases for time scores were noted in trials 51-100 but these performance levels during whole task training never reached the level of performance previously achieved during sub-task training trials 21-50. Standard deviation of MT1 scores decreased systematically during sub-task training and then fluctuated erratically during whole-task training.

The curves of figure 15 display the results of 75 trials of training by the control group on the whole complex perceptual-motor task. The learning score of the control group for the total task was a time decrease of 6.026 seconds for 50 trials of practice and 6.409 seconds for 75 trials. Mean performance time dropped sharply from trials 1-35 then gradually throughout the remaining training trials. Mean performance time increased .224 seconds after interpolated rest. The standard deviation of performance decreased throughout 75 trials of training.

Transfer Effect (RT1). The transfer effect of sub-task training for reaction time (RT1) is summarized in Table IV.

TABLE IV  
THE TRANSFER EFFECT OF REACTION  
TIME AND ITS CONTRIBUTION  
TO TOTAL LEARNING

Group	Whole Task Trials 1-5	Transfer Percentage*
Sub-Task Pivot	3.445	84.9 %
Sub-Task Pass	4.270	52 %
Control	3.514	82 %

\*Limit of Learning for RT1 - 3.074



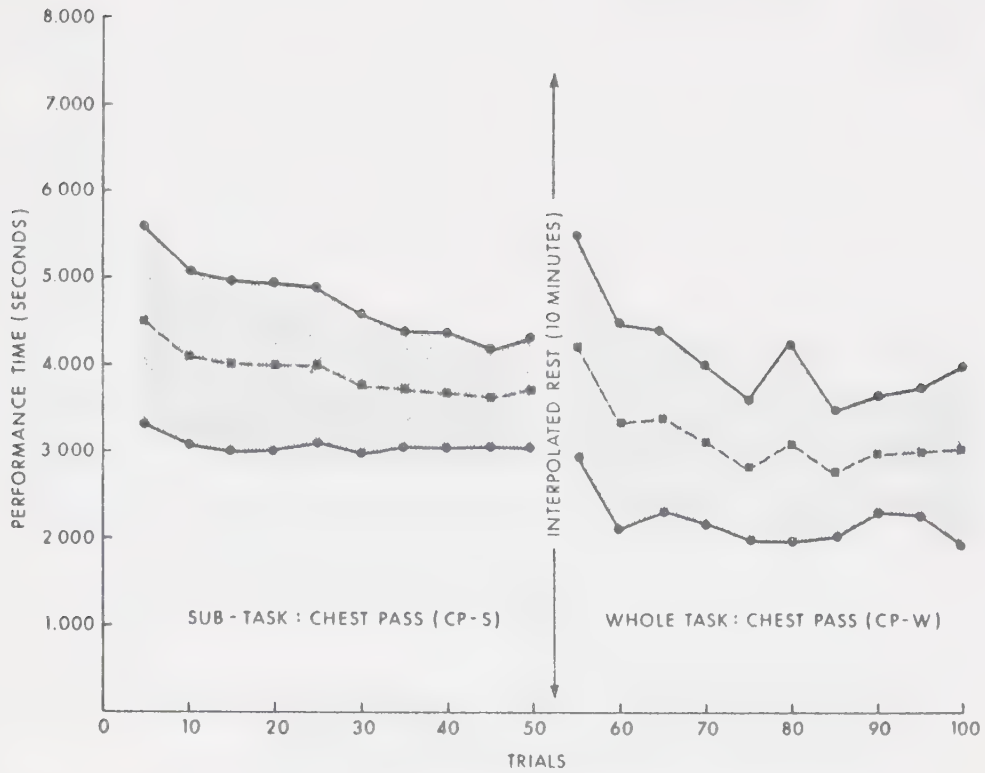


FIGURE 11: MEAN PERFORMANCE TIME AND STANDARD DEVIATION FOR FIVE TRIALS OF EXPERIMENTAL SUB-TASK PASS GROUP ON CHEST PASS OVER 50 TRIALS OF SUB-TASK (PASS) AND OVER 50 TRIALS OF WHOLE TASK.

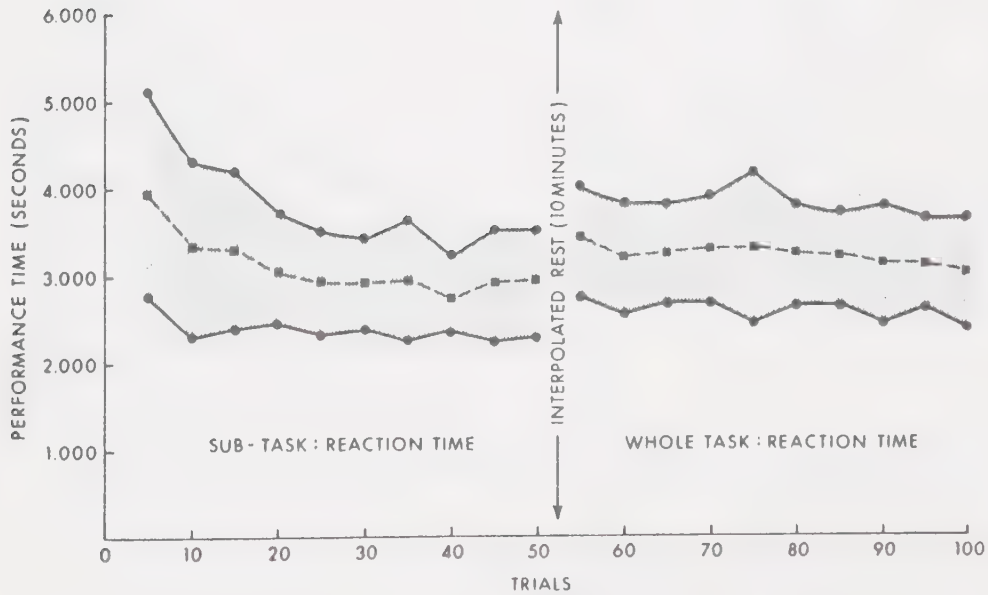


FIGURE 12: MEAN PERFORMANCE TIME AND STANDARD DEVIATION FOR FIVE TRIALS OF EXPERIMENTAL PIVOT GROUP ON REACTION TIME OVER 50 TRIALS OF PART TASK (PIVOT) AND OVER 50 TRIALS OF WHOLE TASK.



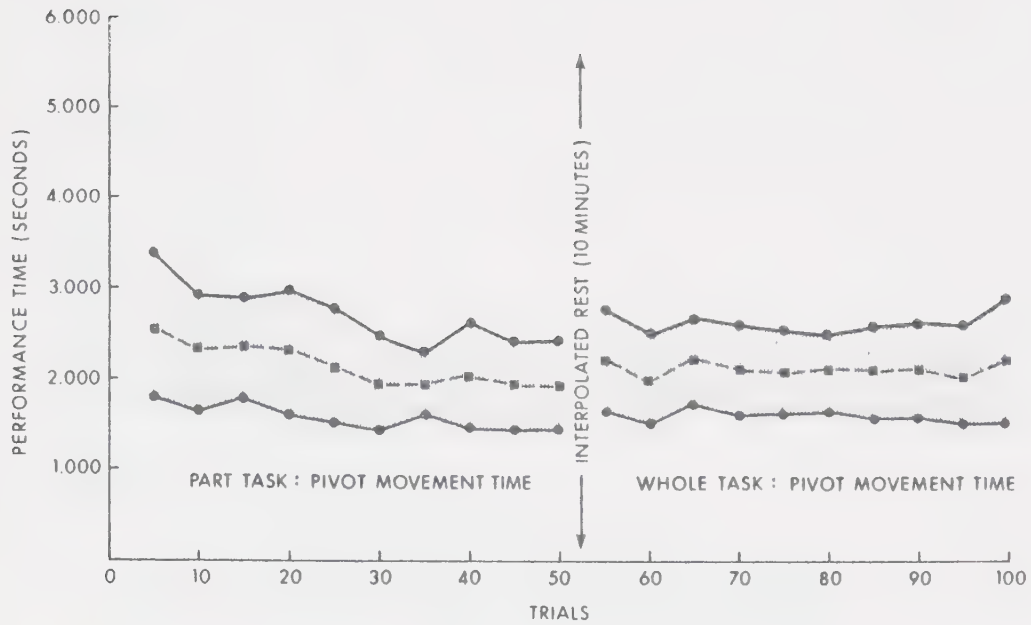


FIGURE 13: MEAN PERFORMANCE TIME AND STANDARD DEVIATION FOR FIVE TRIALS OF EXPERIMENTAL PIVOT GROUP ON PIVOT MOVEMENT TIME OVER 50 TRIALS OF PART TASK(PIVOT) AND OVER 50 TRIALS OF WHOLE TASK.

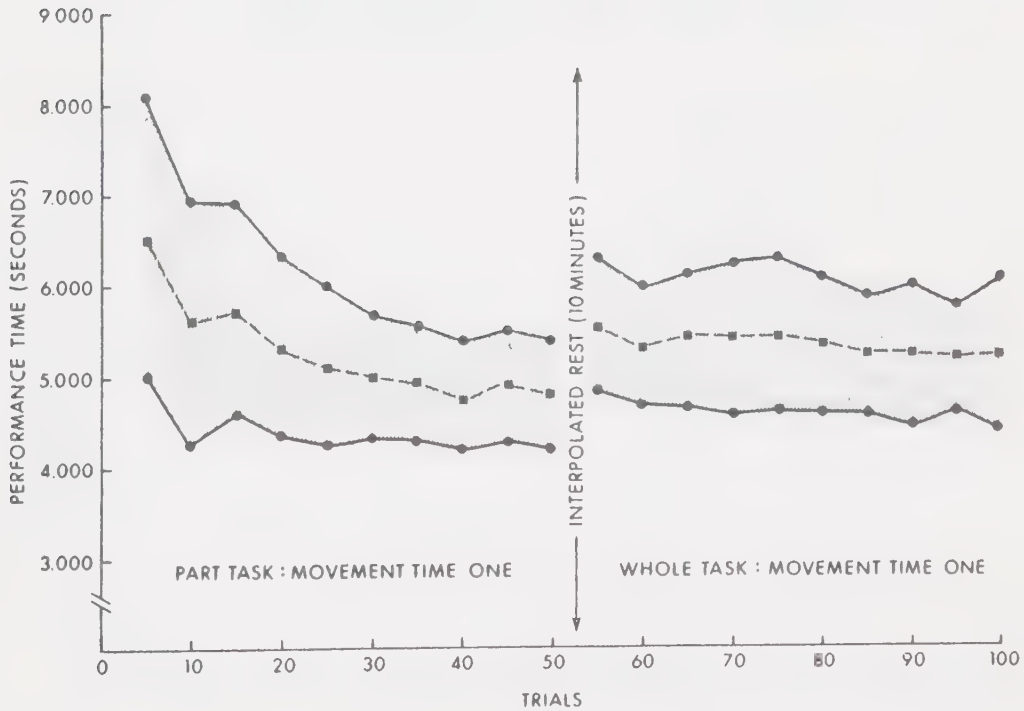


FIGURE 14: MEAN PERFORMANCE TIME AND STANDARD DEVIATION FOR FIVE TRIALS OF EXPERIMENTAL PIVOT GROUP ON MOVEMENT TIME ONE OVER 50 TRIALS OF PART TASK (PIVOT) AND OVER 50 TRIALS OF WHOLE TASK.



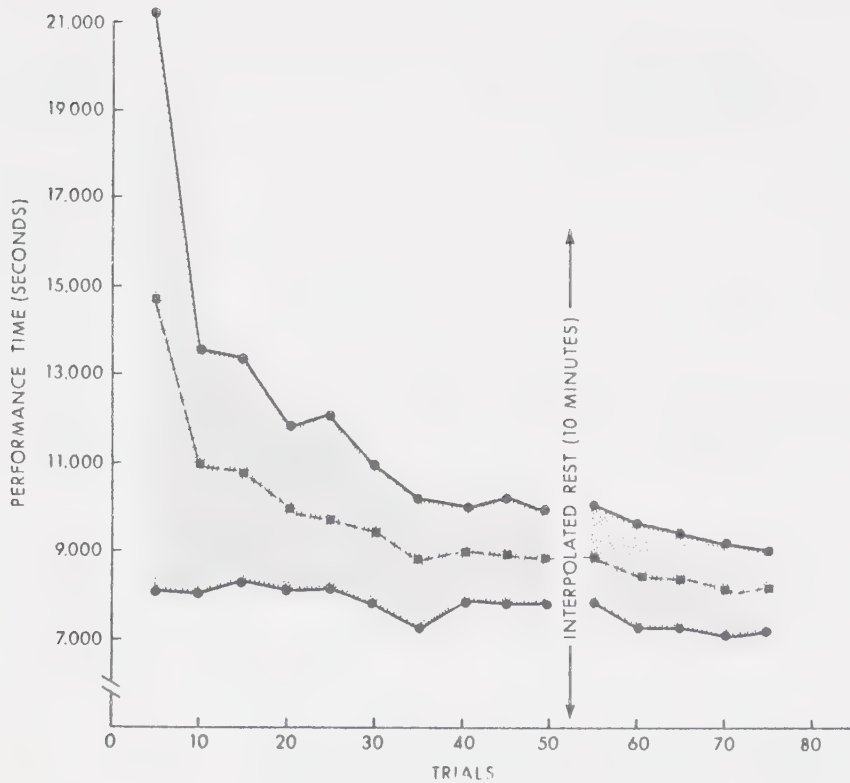


FIGURE 15: MEAN PERFORMANCE TIME AND STANDARD DEVIATION FOR CONTROL GROUP ON MOVEMENT TIME TWO ( $MT_2$ ) ON WHOLE COMPLEX PERCEPTUAL MOTOR TASK.

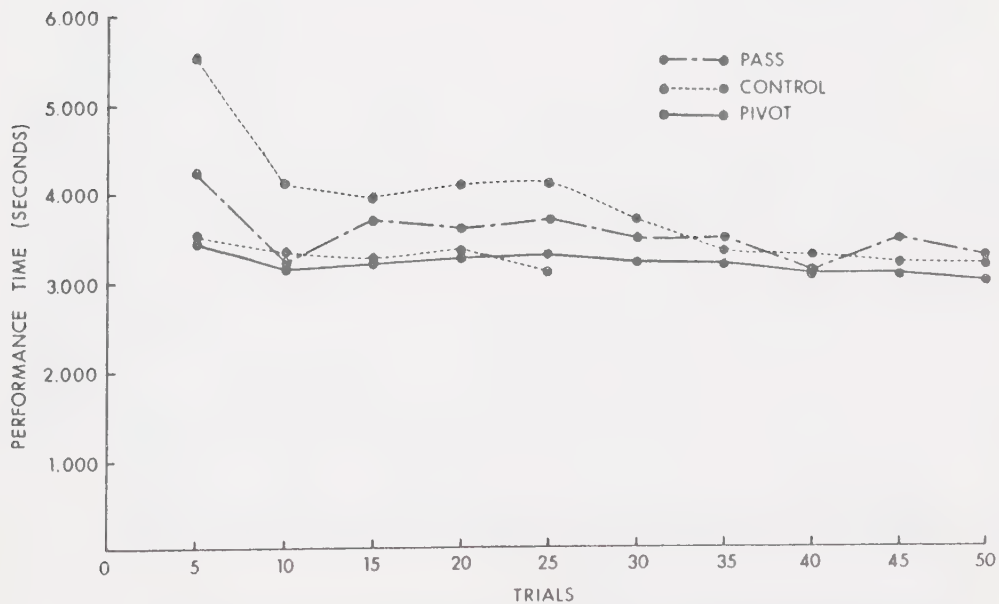


FIGURE 16: MEAN PERFORMANCE TIMES FOR FIVE TRIALS FOR EXPERIMENTAL PIVOT, EXPERIMENTAL PASS AND CONTROL GROUP ON REACTION TIME FOR THE WHOLE TASK.



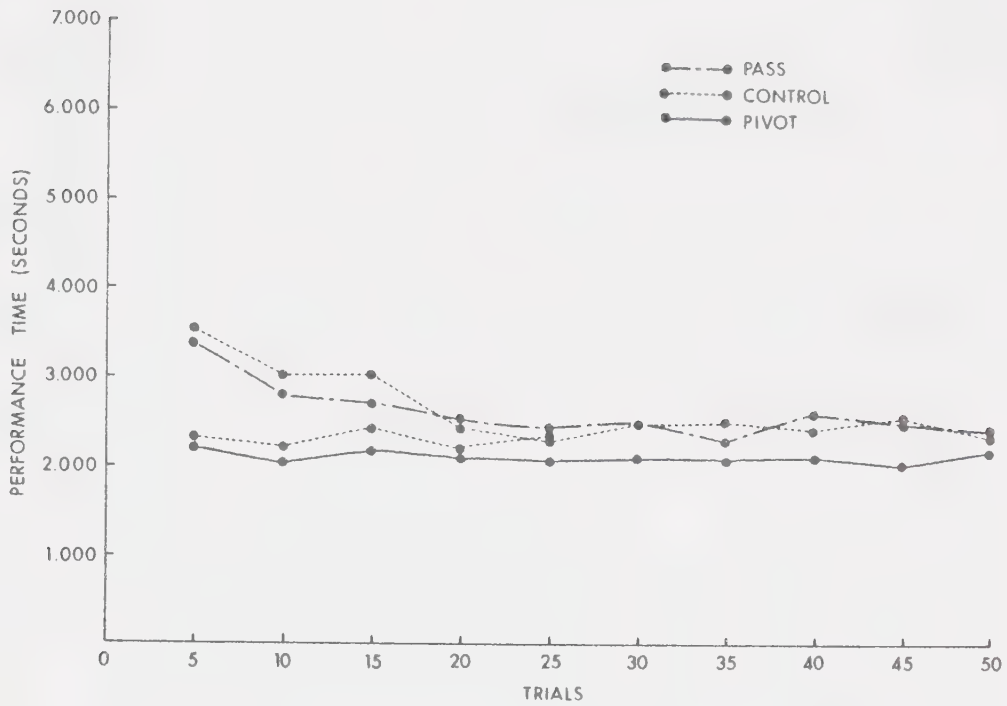


FIGURE 17: MEAN PERFORMANCE TIMES FOR FIVE TRIALS FOR EXPERIMENTAL PASS AND CONTROL GROUP ON PIVOT MOVEMENT TIME FOR THE WHOLE TASK.

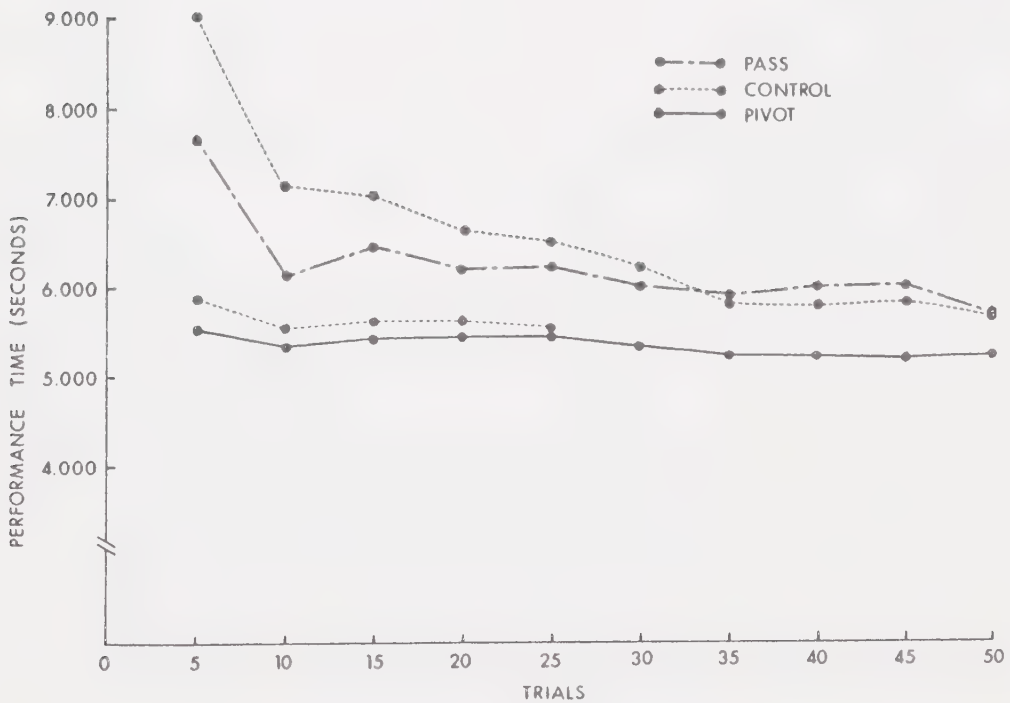


FIGURE 18: MEAN PERFORMANCE TIMES FOR FIVE TRIALS FOR EXPERIMENTAL PIVOT, EXPERIMENTAL PASS AND CONTROL GROUP ON MOVEMENT TIME ONE FOR THE WHOLE TASK.



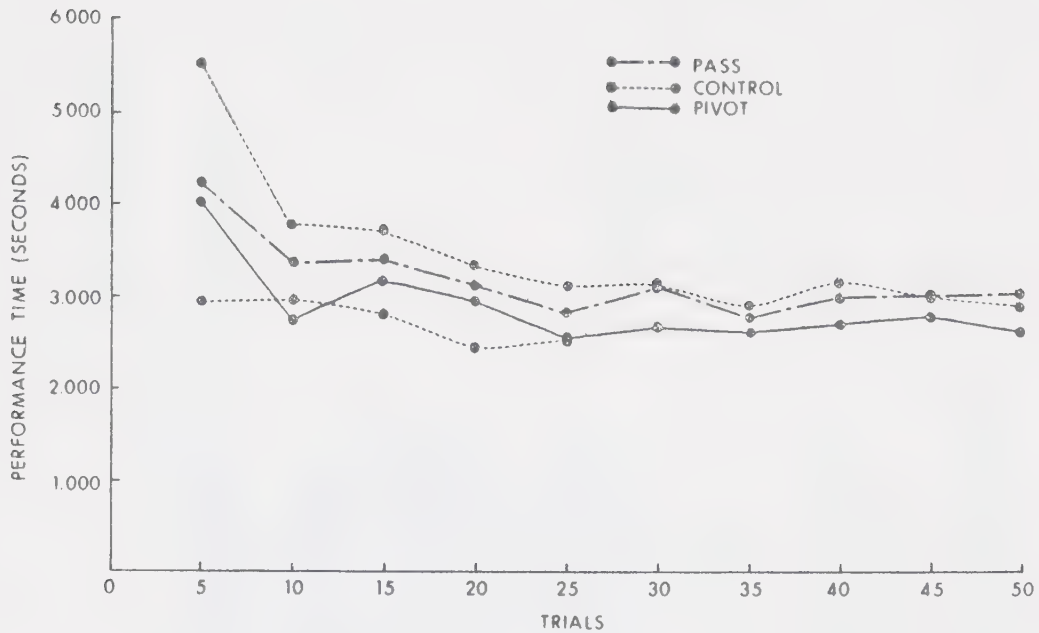


FIGURE 19: MEAN PERFORMANCE TIMES FOR FIVE TRIALS FOR EXPERIMENTAL PIVOT, EXPERIMENTAL PASS AND CONTROL GROUP ON CHEST-PASS-WHOLE FOR THE WHOLE TASK.

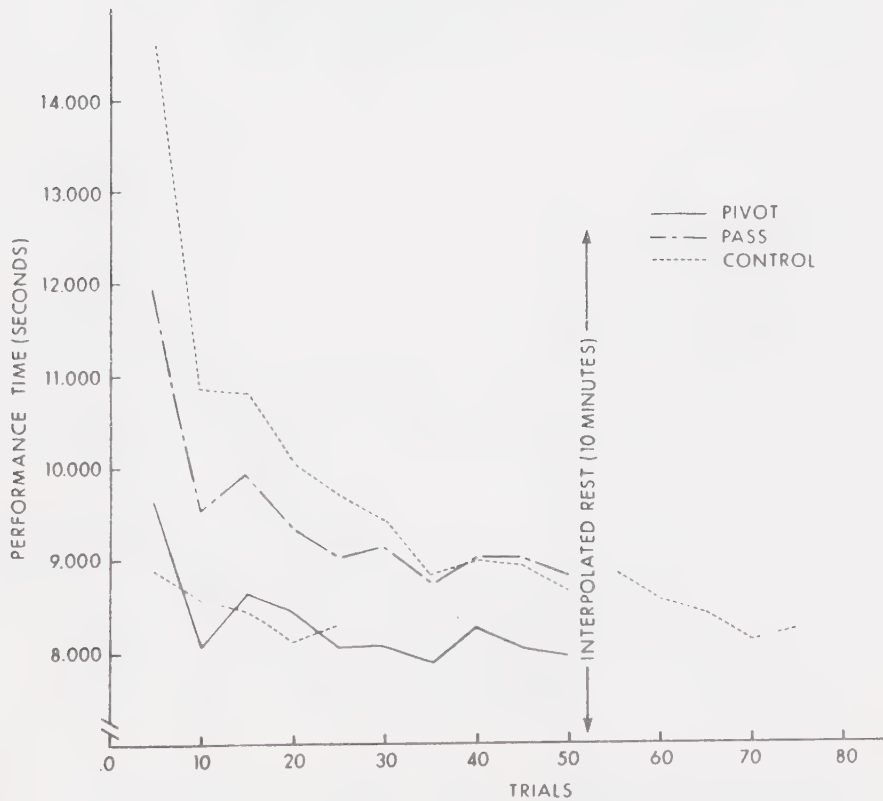


FIGURE 20: MEAN PERFORMANCE TIMES FOR FIVE TRIALS FOR EXPERIMENTAL PIVOT, EXPERIMENT PASS AND CONTROL GROUP ON MOVEMENT TIME TWO FOR THE WHOLE TASK.



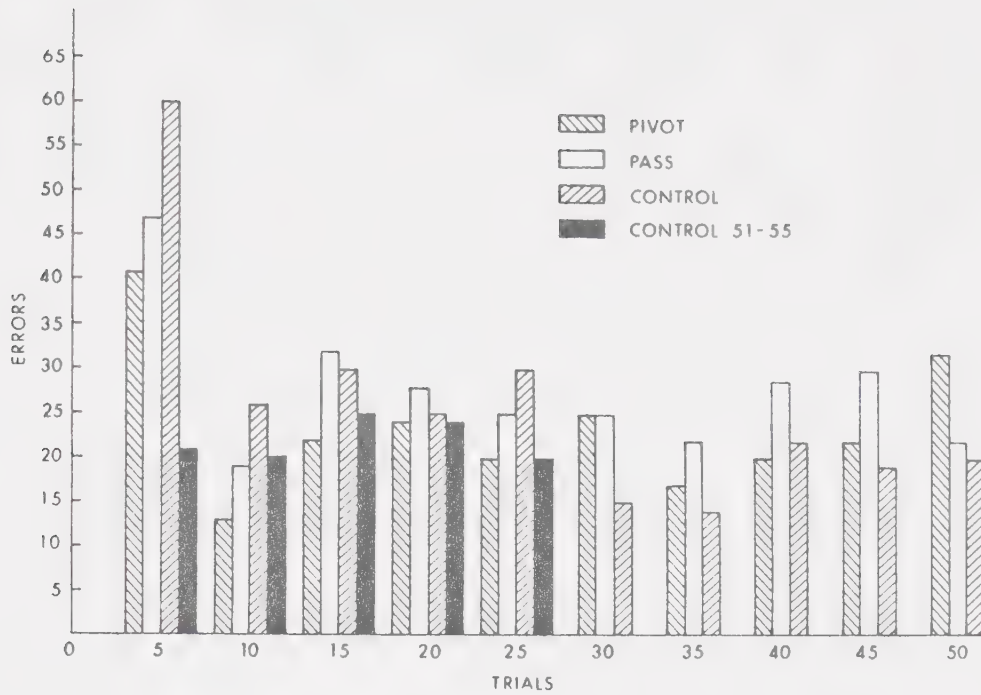


FIGURE 21: SUBJECTIVE ERROR TALLY-TOTAL ERRORS OVER FIFTY TRIALS OF WHOLE TASK TRAINING. CONTROL GROUP TRAINING OVER TRIALS 51 - 75 COMPARED.

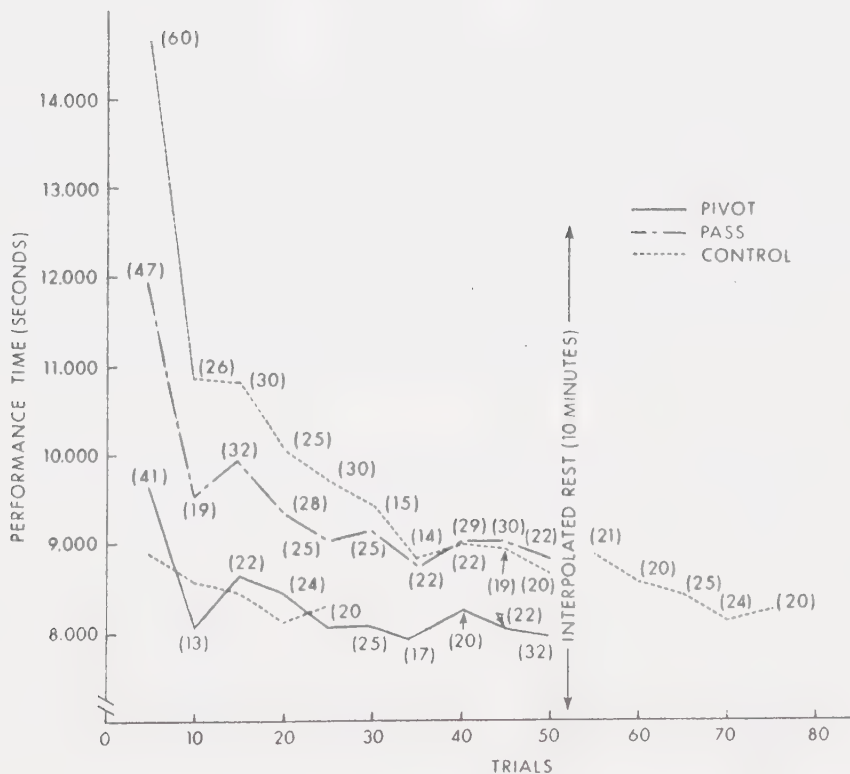


FIGURE 22: RELATIONSHIP BETWEEN SUBJECTIVE ERRORS AND MEAN PERFORMANCE TIMES (MT<sub>2</sub>) FOR EXPERIMENTAL PIVOT, EXPERIMENTAL PASS AND CONTROL GROUP



The percentage of transfer scores presented represent the degree to which transfer, as distinguished from direct practice, has contributed to total learning. The limit of learning (the 100% point) was estimated by using the best RT1 score for five trials (After Gagne 51:107 - see Appendix A for formula). The control group transfer effect (hypothetical) was also calculated to see if training on the whole was as beneficial as sub-task training. Analysis of reaction time results indicate that the training the pivot sub-task group received contributed 84.9% to whole task learning, chest pass sub-task training contributed 52% to the total, while the control group had achieved 82% of the possible learning after 50 trials of whole-task training.

The reaction time scores for three groups were compared graphically (see Figure 16). Control group whole-task training for trials 51-75 was plotted on the graph to illustrate the training results after COMPARABLE numbers of training trials between groups. Figures 17, 18, 19 and 20 also picture this comparison but for different electronic measures.

Reaction Time (RT1) Comparisons Between Groups After Whole Task Training. Tables V, VI, and VII provide a comparison of reaction time (RT1) results at equivalent five trial intervals over 50 trials of training on the whole complex perceptual-motor task.



TABLE V  
COMPARISON OF REACTION TIME ONE BETWEEN  
CONTROL AND SUB-TASK PIVOT  
GROUPS OVER TRIALS 1-50

Trials	Control Mean	Pivot Mean	D	S.E.	t
1-5	5.543	3.445	2.098	.660	3.180**
6-10	4.146	3.225	.921	.249	3.704**
11-15	3.945	3.247	.698	.273	2.555*
16-20	4.133	3.326	.808	.268	3.020**
21-25	4.186	3.368	.818	.312	3.624*
26-30	3.725	3.282	.443	.225	1.968
31-35	3.382	3.229	.153	.205	.747
36-40	3.363	3.159	.203	.199	1.024
41-45	3.274	3.157	.117	.173	.676
46-50	3.278	3.074	.204	.187	1.088

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence

Table V indicates clearly that the sub-task pivot group was significantly superior over the control at trial intervals 1-25. Reaction time means between control and sub-task pivot did not differ significantly over trials 26-50.

TABLE VI  
COMPARISON OF REACTION TIME ONE BETWEEN  
SUB-TASK PASS AND SUB-TASK PIVOT  
GROUPS OVER TRIALS 1-50

Trials	Pass Mean	Pivot Mean	D	S.E.	t
1-5	4.270	3.445	.825	.374	2.207*
6-10	3.365	3.225	.140	.178	.783
11-15	3.789	3.247	.542	.269	.015
16-20	3.658	3.326	.332	.221	1.503
21-25	3.752	3.368	.384	.240	1.598
26-30	3.519	3.282	.237	.218	1.087
31-35	3.622	3.229	.393	.197	1.997
36-40	3.293	3.159	.134	.175	.765
41-45	3.526	3.157	.369	.191	1.935
46-50	3.309	3.074	.235	.176	1.329

\*Significant at the .05 level of Confidence



Table VI shows that the sub-task pivot group had significantly superior reaction performance over the sub-task pass group during trials 1-5. Significant differences were not noted between the two groups over trials 6-50.

TABLE VII  
COMPARISON OF REACTION TIME ONE BETWEEN  
CONTROL AND SUB-TASK PASS  
GROUPS OVER TRIALS 1-50

Trials	Control Mean	Pass Mean	D	S.E.	t
1-5	5.543	4.270	1.274	.737	1.728
6-10	4.146	3.365	.781	.250	3.137**
11-15	3.945	3.789	.156	.343	.455
16-20	4.133	3.658	.476	.309	1.541
21-25	4.186	3.752	.434	.328	1.322
26-30	3.725	3.519	.206	.273	.752
31-35	3.382	3.622	.240	.248	.967
36-40	3.363	3.293	.069	.199	.348
41-45	3.274	3.526	.252	.221	1.139
46-50	3.278	3.309	.031	.198	.158

\*Significant at the .01 level of Confidence

Table VII displays clearly that the sub-task pass group had significantly superior reaction time in trials 6-10. Otherwise mean differences between these groups were not significant.

Tables VIII and IX present a comparison of reaction time (RT1) results between control and experimental groups after COMPARABLE numbers of training trials.



TABLE VIII

COMPARISON OF REACTION TIME ONE BETWEEN  
CONTROL AND SUB-TASK PIVOT GROUPS  
OVER TRIALS 1-25/51-75

Trial	Pivot Mean	Trial	Control Mean	D	S.E.	t
1-5	3.445	51-55	3.514	.069	.212	.328
6-10	3.225	56-60	3.368	.143	.181	.789
11-15	3.247	61-65	3.259	.011	.192	.060
16-20	3.326	66-70	3.409	.083	.183	.455
21-25	3.368	71-75	3.173	.195	.192	1.019

TABLE IX

COMPARISON OF REACTION TIME ONE BETWEEN  
CONTROL AND SUB-TASK PASS GROUPS  
OVER TRIALS 1-25/51-75

Trial	Pass Mean	Trials	Control Mean	D	S.E.	t
1-5	4.270	51-55	3.514	.755	.391	1.931
6-10	3.365	56-60	3.368	.003	.182	.018
11-15	3.789	61-65	3.259	.531	.282	1.882
16-20	3.658	66-70	3.409	.249	.239	1.041
21-25	3.752	71-75	3.173	.580	.217	2.668**

\*\*Significant at the .01 level of Confidence

Results in tables VIII and IX show that trial reaction time means were insignificant after comparable training except at trial levels 21-25/71-75. At this level the control group was significantly better at the .01 level of confidence.

Transfer Effect (PMT). The transfer effect of sub-task training for pivot movement time (PMT) is summarized in Table X.



TABLE X

THE TRANSFER EFFECT OF PIVOT  
MOVEMENT TIME AND ITS CONTRI-  
BUTION TO TOTAL LEARNING

Group	Whole Task Trials 1-5	Transfer Percentage * (Contribution to Total Learning)
Sub-Task Pivot	2.219	91.5%
Sub-Task Pass	3.428	12.7%
Control (Comparable Training)	2.361	81.4%

\*Limit of learning for PMT - 2.099

The transfer effect of sub-task training for pivot movement time (PMT) is summarized in Table X. Results indicate that pivot sub-task training contributed 91.5% to whole task pivot movement time learning, chest pass sub-task training contributed 12.7% to the total, while the control group had achieved 81.4% of the possible learning after 50 trials of whole-task training.

Pivot Movement Time (PMT) Comparisons Between Groups After Whole Task Training. The PMT scores for three groups were compared graphically (see figure 17). The sub-task pivot group shows a plateau or asymptotic effect for PMT while the other two groups show gradual time decreases in trials 1-20 after which a plateau effect was noted.

A comparison of PMT results at equivalent 5 trial intervals over 50 trials of whole-task training is summarized in Tables XI, XII, and XIII.



TABLE XI  
COMPARISON OF PIVOT MOVEMENT TIME  
BETWEEN CONTROL AND SUB-TASK  
PIVOT GROUPS OVER TRIALS 1-50

Trials	Control Mean	Pivot Mean	D	S.E.	t
1-5	3.508	2.219	1.288	.282	4.573**
6-10	3.047	2.071	.976	.229	4.261**
11-15	3.083	2.235	.849	.163	5.198**
16-20	2.487	2.139	.348	.141	2.479*
21-25	2.343	2.106	.237	.140	1.689
26-30	2.516	2.128	.387	.133	2.918**
31-35	2.538	2.109	.429	.153	2.805**
36-40	2.472	2.167	.305	.137	2.222*
41-45	2.601	2.011	.502	.153	3.289**
46-50	2.423	2.215	.208	.169	1.231

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence

Table XI displays clearly that the sub-task pivot group was significantly superior over the control at all trial levels except 20-25 and 46-50.

TABLE XII  
COMPARISON OF PIVOT MOVEMENT TIME  
BETWEEN SUB-TASK PASS AND  
SUB-TASK PIVOT GROUPS OVER  
TRIALS 1-50

Trial	Pass Mean	Pivot Mean	D	S.E.	t
1-5	3.428	2.219	1.208	.332	3.638**
6-10	2.816	2.071	.745	.194	3.846**
11-15	2.701	2.235	.467	.240	1.944
16-20	2.578	2.139	.439	.206	2.130*
21-25	2.484	2.106	.378	.223	1.696
26-30	2.526	2.128	.398	.202	1.966
31-35	2.312	2.109	.202	.196	1.030
36-40	2.680	2.167	.512	.234	2.190*
41-45	2.510	2.099	.411	.210	1.962
46-50	2.469	2.215	.255	.190	1.342

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence



It can be observed in Table XII that the sub-task pivot group had significantly superior PMT performances during trials levels 1-5, 6-10, 16-20, and 36-40.

TABLE XIII  
COMPARISON OF PIVOT MOVEMENT TIME  
BETWEEN CONTROL AND SUB-TASK  
PASS GROUP OVER TRIALS 1-50

Trials	Capital - X	Pass X	D	S.E.	t
1-5	3.508	3.428	.080	.408	.196
6-10	3.047	2.816	.232	.271	.856
11-15	3.083	2.701	.382	.265	1.442
16-20	2.487	2.578	.090	.212	.427
21-25	2.343	2.484	.142	.230	.615
26-30	2.516	2.526	.010	.210	.049
31-35	2.538	2.312	.226	.207	1.092
36-40	2.472	2.680	.207	.237	.875
41-45	2.601	2.510	.091	.221	.409
46-50	2.423	2.469	.046	.191	.243

Table XIII indicates that differences between groups on PMT were not significant throughout 50 trials of whole-task training.

Tables XIV and XV provide a comparison of PMT results between control and experimental groups after COMPARABLE numbers of training trials.

TABLE XIV  
COMPARISON OF PIVOT MOVEMENT TIME BETWEEN  
CONTROL AND SUB-TASK PIVOT GROUPS  
OVER TRIALS 1-25/51-75

Trials	Pivot Mean	Trials	Control Mean	D	S.E.	t
1-5	2.219	51-55	2.361	.142	.161	.881
6-10	2.071	56-60	2.238	.168	.137	1.226
11-15	2.235	61-65	2.458	.223	.143	1.563
16-20	2.139	66-70	2.245	.106	.142	.749
21-25	2.106	71-75	2.408	.302	.151	1.997



TABLE XV  
COMPARISON OF PIVOT MOVEMENT TIME  
BETWEEN CONTROL AND SUB-TASK  
PASS GROUPS OVER TRIALS  
1-25/51-75

Trials	Pass Mean	Trials	Control Mean	D	S.E.	t
1-5	3.428	51-55	2.361	1.067	.337	3.170**
6-10	2.816	56-60	2.238	.577	.198	2.909**
11-15	2.701	61-65	2.458	.244	.253	.963
16-20	2.578	66-70	2.245	.333	.212	1.566
21-25	2.484	71-75	2.468	.077	.237	.323

\*\*Significant at the .01 level of Confidence

Tables XIV and XV present differences which are insignificant at all levels except trials 1-10/51-60 in Table XV. At these trial levels the control group was significantly better than the sub-task pass group.

Transfer Effect. The transfer effect of sub-task training for Movement Time One (MT1) is summarized in Table XVI.

TABLE XVI  
THE TRANSFER EFFECT OF MOVEMENT  
TIME ONE AND ITS CONTRIBUTION  
TO TOTAL LEARNING

Group	Whole Task Trial 1-5	Transfer Percentage* (Contribution to Total Learning)
Sub-Task Pivot	5.593	98.1%
Sub-Task Pass	7.664	36.3%
Control-Comparable Training	5.877	82.8%

\*Limit of learning for MT1 - 5.220

Results indicate that pivot sub-task training contributed 98.1% to whole task learning, chest pass sub-task training contributed 36.3%



to the total, while the control group had achieved 82.8 of the possible learning after 50 trials of whole-task training.

Movement Time One Scores (MT1) Comparison Between Groups After Whole Task Training. The MT1 scores for three groups were compared graphically (see Figure 18).

The sub-task pivot group displayed a plateau or asymptotic effect for MT1 over trials 1-50. The control and sub-task pass group had marked decreases in MT1 scores in trials 1-10 after which gradual decreases are apparent. The control groups performance on trials 55-75 pictures a plateau effect.

Tables XVII, XVIII, and XIX display MT1 results at equivalent five trial intervals over 50 trials of whole-task training.

TABLE XVII

COMPARISON OF MOVEMENT TIME ONE BETWEEN  
CONTROL AND SUB-TASK PIVOT GROUPS OVER  
TRIALS 1-50

Trials	Control Mean	Pivot Mean	D	S.E.	t
1-5	9.050	5.593	3.457	.817	4.230**
6-10	7.160	5.328	1.831	.310	5.904**
11-15	7.059	5.484	1.575	.310	5.073**
16-20	6.684	5.460	1.224	.282	4.336**
21-25	6.532	5.481	1.051	.310	3.393**
26-30	6.240	5.390	.850	.227	3.749**
31-35	5.839	5.245	.594	.208	2.856**
36-40	5.831	5.260	.571	.204	2.795**
41-45	5.889	5.220	.669	.172	3.890**
46-50	5.700	5.276	.424	.196	2.169*

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence



Table XVII displays clearly that the sub-task pivot group was significantly superior at all trial levels.

TABLE XVIII

COMPARISON OF MOVEMENT TIME ONE BETWEEN  
SUB-TASK PASS AND SUB-TASK PIVOT  
GROUPS OVER TRIALS 1-50

Trials	Pass Mean	Pivot Mean	D	S.E.	t
1-5	7.664	5.593	2.070	.537	3.857**
6-10	6.180	5.328	.852	.220	3.879**
11-15	6.494	5.484	1.010	.308	3.273**
16-20	6.222	5.460	.762	.265	2.875**
21-25	6.240	5.481	.759	.241	3.143**
26-30	6.011	5.390	.621	.236	2.631**
31-35	5.929	5.245	.684	.229	2.988**
36-40	6.056	5.260	.796	.298	2.675**
41-45	6.035	5.220	.815	.229	3.563**
46-50	5.747	5.276	.815	.220	2.138*

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence

Table XVIII figures indicate that the sub-task pivot group was significantly superior over the sub-task pass group at all trial levels 1-50.

TABLE XIX

COMPARISON OF MOVEMENT TIME ONE BETWEEN  
CONTROL AND SUB-TASK PASS GROUPS  
OVER TRIALS 1-50

Trials	Control Mean	Pass Mean	D	S.E.	t
1-5	9.050	7.664	1.387	.960	2.831**
6-10	7.160	6.180	.979	.346	1.444
11-15	7.059	6.494	.565	.391	1.444
16-20	6.684	6.222	.462	.324	1.427
21-25	6.532	6.240	.293	.328	.892
26-30	6.240	6.011	.229	.271	.844
31-35	5.839	5.929	.091	.867	.339
36-40	5.831	6.056	.225	.299	.752
41-45	5.889	6.035	.146	.238	.615
46-50	5.700	5.747	.047	.208	.224

\*\*Significant at the .01 level of Confidence



The control group performed significantly better than the sub-task pass group at trial level 1-15 as pictured in Table XIX. Differences were not significant at subsequent trial levels beyond trial 15.

A comparison of MT1 results between control and experimental groups after COMPARABLE number of training trials is presented in Tables XX and XXI.

TABLE XX  
COMPARISON OF MOVEMENT TIME ONE BETWEEN  
CONTROL AND SUB-TASK PASS GROUPS  
OVER TRIALS 1-25/51-75

Trials	Pass Mean	Trials	Control Mean	D	S.E.	t
1-5	7.664	51-55	5.877	1.787	.535	3.338**
6-10	6.180	56-60	5.585	.596	.223	2.667**
11-15	6.494	61-65	5.646	.847	.295	2.873**
16-20	6.222	66-70	5.629	.593	.235	2.523*
21-25	6.240	71-75	5.560	.679	.227	2.995**

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence

The control group was significantly superior over the sub-task pass group at all levels compared as represented in Table XX.

TABLE XXI  
COMPARISON OF MOVEMENT TIME ONE BETWEEN  
CONTROL AND SUB-TASK PIVOT GROUPS  
OVER TRIALS 1-25/51-75

Trials	Pivot Mean	Trials	Control Mean	D	S.E.	t
1-5	5.593	51-55	5.877	.283	.180	1.571
6-10	5.328	56-60	5.885	.256	.163	1.577
11-15	5.484	61-65	5.646	.163	.174	.935
16-20	5.460	66-70	5.629	.169	.173	.976
21-25	5.481	71-75	5.560	.079	.200	.398



The mean differences between control and sub-task pivot groups present in Table XXI were insignificant.

Transfer Effect (CP-W). The transfer effect of sub-task training for chest pass time is summarized in Table XXII.

TABLE XXII  
THE TRANSFER EFFECT OF CHEST  
PASS TIME AND ITS CONTRIBUTION  
TO TOTAL LEARNING

Group	Whole Task Trials 1-5	Transfer Percentage* (Contribution to total Learning)
Sub-Task Pivot	4.078	48.2%
Sub-Task	4.264	42.2%
Control (Comparable training)	2.964	84.3%

\*Limit of Learning for CP-W-2.481

The transfer effects of sub-task training for CP-W are displayed in Table XXII. Results indicate that pivot sub-task training contributed 48.2% to whole task learning, chest pass sub-task training contributed 42.2% to the total, while the control group had achieved 84.3% of the possible CP-W learning after 50 trials of whole-task training.

Chest Pass Time Scores (CP-W) Comparisons Between Groups After Whole Task Training. The CP-W scores for three groups were compared graphically in figure 19.

The pivot group had better performance times than the control or sub-task pass group through trials 1-50 of whole-task training as pictured in figure 19. The control group has the better performance curve when comparable training trials are plotted. Marked decreases in time scores for all groups was noted in trials 1-10. In trials 11-25 slight decreases



are noted as performance improves. A plateauing effect was noted in trial levels beyond 25 for all groups.

A comparison at equivalent 5 trial intervals over 50 trials of whole-task training is summarized in Tables XXIII, XXIV, and XXV.

TABLE XXIII  
COMPARISON OF CHEST PASS TIMES  
BETWEEN CONTROL AND SUB-TASK  
PIVOT GROUPS OVER TRIALS  
1-50

Trials	Control Mean	Pivot Mean	D	S.E.	t
1-5	5.567	4.079	1.488	.514	2.895**
6-10	3.822	2.755	1.068	.340	3.143**
11-15	3.780	3.207	.573	.277	2.066*
16-20	3.366	2.991	.375	.217	1.723
21-25	3.147	2.562	.584	.210	2.781**
26-30	3.195	2.700	.495	.199	2.490*
31-35	2.918	2.665	.253	.163	1.554
36-40	3.210	3.042	.169	.196	.862
41-45	3.028	2.834	.195	.187	1.039
46-50	2.989	2.674	.316	.158	2.003*

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence

Results depicted in Table XXIII show that the sub-task pivot group was significantly superior at trial levels 1-15, 21-30, and 46-50.



The control and sub-task pass group means summarized in Table XXV are not significantly different except at trial interval 1-5. At this stage the pass group is superior.

A comparison of CP-W results between control and experimental groups after COMPARABLE numbers of training trials is displayed in Tables XXVI and XXVII.

TABLE XXVI  
COMPARISON OF CHEST PASS TIMES  
BETWEEN CONTROL AND SUB-TASK  
PIVOT GROUPS OVER TRIALS  
1-25/51-75

Trials	Class Mean	Trials	Control Mean	D	S.E.	t
1-5	4.264		2.964	1.114	.271	4.794**
6-10	3.366		2.995	.241	.277	1.341
11-15	3.431		2.828	.379	.245	2.459*
16-20	3.145		2.481	.511	.204	3.257**
21-25	2.849		2.679	.117	.207	.819

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence

The control group, as shown in Table XXVI, was significantly superior at trial intervals 1-5 and 11-20.

TABLE XXVII  
COMPARISON OF CHEST PASS TIMES  
BETWEEN CONTROL AND SUB-TASK  
PASS GROUPS OVER TRIALS  
1-25/51-75

Trials	Pivot Mean	Trials	Control Mean	D	S.E.	t
1-5	4.079	51-55	2.964	1.300	.192	5.803**
6-10	2.755	56-60	2.985	.371	.187	1.285
11-15	3.207	61-65	2.828	.603	.190	2.000*
16-20	2.991	66-70	2.481	.664	.171	2.995**
21-25	2.562	71-75	2.679	.170	.163	.716

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence



The control and sub-task pass group means summarized in Table XXV are not significantly different except at trial interval 1-5. At this stage the pass group is superior.

A comparison of CP-W results between control and experimental groups after COMPARABLE numbers of training trials is displayed in Tables XXVI and XXVII.

TABLE XXVI  
COMPARISON OF CHEST PASS TIMES  
BETWEEN CONTROL AND SUB-TASK  
PIVOT GROUPS OVER TRIALS  
1-25/51-75

Trials	Pivot Mean	Trials	Control Mean	D	S.E.	t
1-5	4.264	51-55	2.964	1.114	.271	4.794**
6-10	3.366	56-60	2.995	.241	.277	1.341
11-15	3.431	61-65	2.828	.379	.245	2.459*
16-20	3.145	66-70	2.481	.511	.204	3.257**
21-25	2.849	71-75	2.679	.117	.207	.819

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence

The control group, as shown in Table XXVI, was significantly superior at trial intervals 1-5 and 11-20.

TABLE XXVII  
COMPARISON OF CHEST PASS TIMES  
BETWEEN CONTROL AND SUB-TASK  
PASS GROUPS OVER TRIALS  
1-25/51-75

Trials	Pass Mean	Trials	Control Mean	D	S.E.	t
1-5	4.079	51-55	2.964	1.300	.192	5.803**
6-10	2.755	56-60	2.985	.371	.187	1.285
11-15	3.207	61-65	2.828	.603	.190	2.000*
16-20	2.991	66-70	2.481	.664	.171	2.995**
21-25	2.562	71-75	2.679	.170	.163	.716

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence



In Table XXVII the control group was significantly superior at trial intervals 1-5 and 11-20.

Transfer Effect (MT2). The transfer effect of sub-training for movement time two (MT2) is summarized in Table XXVIII.

TABLE XXVIII  
THE TRANSFER EFFECT OF MOVEMENT  
TIME TWO AND ITS CONTRIBUTION  
TO TOTAL LEARNING

Group	Whole Task Trials 1-5	Transfer Percentage* (Contribution to Total Learning)
Sub-Task Pivot	9.626	74.4%
Sub-Task Pass	11.925	40.6%
Control (Comparable Training)	8.876	85.5%

\*Limit of Learning for MT2 - 7.894

The transfer effects of sub-task training for MT2 are presented in Table XXVIII. Pivot sub-task training contributed 74.4% to whole task learning, chest pass sub-task training contributed 40.6% to the total, while the control group had achieved 85.5% of the possible MT2 learning after 50 trials of whole-task training.

Movement Time Two (MT2) Comparisons Between Groups After Whole Task Training. The MT2 scores for three groups was compared graphically in figure 20. Marked decreases in time scores for all three groups was evident at trial intervals 1-10. Gradual decreases in time scores were noted in trials 15-35 followed by time score increases in trials 36-40. Stabilization of performance was noted in trials 41-50 with slight time decreases for the pivot and control groups. Control group time scores decreased systematically in trials 51-75.



A comparison of the MT2 results at equivalent 5 trial intervals over 50 trials of whole-task training is pictured in Tables XXIX, XXX, and XXXI.

TABLE XXIX  
COMPARISON OF MOVEMENT TIME TWO  
BETWEEN CONTROL AND SUB-TASK  
PIVOT GROUPS OVER TRIALS  
1-50

Trials	Control Mean	Pivot Mean	D	S.E.	t
1-5	14.678	9.626	5.052	1.212	4.168**
6-10	10.880	8.081	2.799	.552	5.068**
11-15	10.827	8.648	2.179	.516	4.223**
16-20	10.060	8.450	1.611	.424	3.798**
21-25	9.701	8.038	1.663	.476	3.494**
26-30	9.444	8.049	1.395	.336	4.155**
31-35	8.808	7.894	.914	.320	2.857**
36-40	9.000	8.242	.758	.300	2.526**
41-45	8.939	8.029	.910	.283	3.217**
46-50	8.652	7.929	.723	.286	2.527*

\*\*Significant at the .05 level of Confidence

\* Significant at the .01 level of Confidence

The pivot sub-task group was significantly superior at all trial levels 1-50 over the control group as noted in Table XXIX.



TABLE XXX  
COMPARISON OF MOVEMENT TIME TWO  
BETWEEN SUB-TASK PASS AND SUB-  
TASK PIVOT GROUPS OVER TRIALS  
1-50

Trials	Pass Mean	Pivot Mean	D	S.E.	t
1-5	11.925	9.626	2.299	.631	3.641**
6-10	9.547	8.081	1.466	.394	3.723**
11-15	9.928	8.648	1.280	.492	2.602*
16-20	9.366	8.450	.916	.388	2.364*
21-25	9.089	8.038	1.050	.278	2.777**
26-30	9.171	8.049	1.122	.392	2.859**
31-35	8.730	7.894	.836	.314	2.664**
36-40	9.011	8.242	.769	.367	2.096*
41-45	9.065	8.029	1.035	.313	3.310**
46-50	8.816	7.929	.887	.359	2.472*

\*\*Significant at the .01 level of Confidence

\* Significant at the .05 level of Confidence

Performance scores for the sub-task pivot group were significantly superior to the pass group (see Table XXX) at all trial intervals 1-50.

TABLE XXXI  
COMPARISON OF MOVEMENT TIME TWO  
BETWEEN SUB-TASK PASS AND  
CONTROL GROUPS OVER TRIALS  
1-50

Trials	Control Mean	Pass Mean	D	S.E.	t
1-5	14.678	11.925	2.753	1.326	2.077*
6-10	10.880	9.547	1.333	.631	2.113*
11-15	10.827	9.928	.899	.631	1.424
16-20	10.060	9.366	.694	.475	1.462
21-25	9.701	9.089	.613	.517	1.185
26-30	9.444	9.171	.273	.465	.587
31-35	8.808	8.730	.078	.383	.202
36-40	9.000	9.011	.011	.365	.031
41-45	8.939	9.065	.125	.347	.361
46-50	8.652	8.816	.164	.364	.451

\*Significant at the .01 level of Confidence



The sub-task pass group (see Table XXXI) had significantly superior performance times over the control group at trial intervals 1-10.

A comparison of MT2 results between control and experimental groups after COMPARABLE NUMBERS of training trials is displayed Tables XXXII and XXXIII.

TABLE XXXII

COMPARISON OF MOVEMENT TIME TWO  
BETWEEN CONTROL AND SUB-TASK  
PIVOT GROUPS OVER TRIALS  
1-25/51-75

Trial	Pivot Mean	Trial	Control Mean	D	S.E.	t
1-5	9.626	50-55	8.876	.750	.315	2.379*
6-10	8.081	56-60	8.583	.502	.288	1.743
11-15	8.647	61-65	8.478	.170	.307	.552
16-20	8.450	66-70	8.109	.341	.291	1.169
21-25	8.038	71-75	8.269	.231	.286	.808

\*Significant at .05 level of Confidence

Table XXXII shows that the control group had significantly better time scores than the pivot group at trial interval 1-5. Mean differences between control and pivot groups are not significant at subsequent trial intervals 6-25/56-75.

TABLE XXXIII

COMPARISON OF MOVEMENT TIME TWO  
BETWEEN CONTROL AND SUB-TASK  
PASS GROUPS OVER TRIALS  
1-25/51-75

Trials	Pass Mean	Trial	Control Mean	D	S.E.	t
1-5	11.925	50-55	8.876	3.048	.623	4.895**
6-10	9.547	56-60	8.583	.963	.420	2.295*
11-15	9.928	61-65	8.478	1.450	.475	3.050**
16-20	9.366	66-70	8.109	1.257	.361	3.480**
21-25	9.089	71-75	8.269	.819	.350	2.339*

\*\*Significant at the .01 level of Confidence

\*Significant at the .05 level of Confidence



Performance comparisons between the control group and sub-task pass group indicate that the control group had significantly better scores at all trial intervals 1-25/51-75.

Subjective Error Tally. Four performance errors were identified during pilot work. If a subject committed errors during performance the tester subjectively assessed the type of error and recorded it. A graphical summary of the total errors committed by all groups is presented in figure 21. The control group error score for comparable training was noticeably lower than the pivot or pass experimental groups. The error score difference is quite marked (see figure 21) at trial level 1-5/51-55 of comparable training. Figure 22 supports the information displayed in Figure 21. The control group in Figure 22 has fewer errors (110) than either the sub-task pivot (120) or the sub-task pass (151) group after comparable training. Error scores analysis after comparable training indicates that the control group had 8.33% fewer errors than the pivot group and 29.49% fewer errors than the pass group after comparable training. All three groups had the fewest errors at trial interval 35 after which errors for all groups increase. Inspection of Figure 22 also displays that 10 out of 15 time score plots for the control group were related to error score. The learning curve for the sub-task pass group indicates that in 9 plots out of 10, a decrease or increase in time score was related to the error score. The pivot sub-task group had 7 out of 10 time score plots related to an increase or decrease in error score.

Totalling all score plots it was found that 26 out of 35 or 74.2% were related to an increase or decrease in the error score.

Subjective error tally information relative to total error, pivot wrong way, hit hoop, wrong hoop, and incorrect chest pass errors are presented in Tables XXXIV, XXXV, XXXVI, XXXVII, and XXXVIII.



TABLE XXXIV

COMPARISON OF TOTAL ERRORS  
BETWEEN CONTROL, PIVOT,  
AND PASS GROUPS

Group	Trials 1-5	6-10	11-15	16-20	21-25	Total for 25 Trials
*128-Pivot	41	13	22	24	20	120
*119-Pass	47	19	32	28	25	151
Control	60	26	30	25	30	171
**Control	(21)	(20)	(25)	(24)	(20)	110

\*Errors committed during sub-task training

\*\*Error tally after comparable training

TABLE XXXV

COMPARISON OF PIVOT WRONG WAY ERRORS  
BETWEEN CONTROL, PIVOT, AND  
PASS GROUPS

Group	Trials 1-5	6-10	11-15	16-20	21-25	Total for 25 Trials
* 87-Pivot	10	8	5	10	8	41
Pass	24	12	7	8	7	58
Control	31	17	14	12	15	99
**Control	( 3)	( 4)	( 4)	( 4)	( 4)	19

\* Errors committed during pivot sub-task training

\*\*Error tally after comparable training



TABLE XXXVI  
COMPARISON OF HITTING HOOP ERRORS  
BETWEEN CONTROL, PIVOT, AND  
PASS GROUPS

Group	Trials					Total for 25 Trials
	1-5	6-10	11-15	16-20	21-25	
Pivot	13	2	8	6	7	36
*35-Pass	7	4	13	5	6	35
Control	5	4	6	8	7	30
** Control	( 8)	( 8)	(14)	( 9)	( 9)	48

\*Errors committed during chest pass sub-task training

\*\*Error tally after comparable training

TABLE XXXVII  
COMPARISON OF PASSING THROUGH  
WRONG HOOP ERRORS BETWEEN  
CONTROL, PIVOT, AND  
PASS GROUPS

Group	Trials					Total for 25 Trials
	1-5	6-10	11-15	16-20	21-25	
Pivot	5	0	5	3	2	15
*6 -Pass	5	1	5	2	3	16
Control	11	2	3	4	5	25
** Control	( 6)	( 6)	( 4)	( 3)	( 4)	23

\*Errors committed during chest pass sub-task training

\*\*Error tally after comparable training



TABLE XVIII  
COMPARISON OF INCORRECT PASS  
PATTERN BEHAVIOR BETWEEN PIVOT,  
PASS, AND WHOLE TASK

Group	Totals	Pivot	Pass	Whole	Total for 15 Trials
Pivot	10	0	0	0	32
* Pass	11	0	0	0	41
Control	10	0	0	0	25
** Control	4	0	0	0	20

\*Pivot control group (pass pass sub-task training)  
\*\*Pivot control group (whole task training)

#### Discussion

The purpose of this study was to investigate whether practice on sub-tasks of a complex perceptual-motor task are beneficial. Several hypotheses are presented which examine the purpose of the study:

H<sub>1</sub>: Training on the whole complex task = part training on pivot sub-task.

H<sub>2</sub>: Training on the whole complex task = part training on pass sub-task.

H<sub>3</sub>: Training on pivot sub-task = training on pass sub-task.

H<sub>4</sub>: Whole task training = sub-task pass training = pivot sub-task training.

H<sub>5</sub>: Training on the whole complex task = part training on pivot sub-task. The null hypothesis is supported by results presented in Tables VIII, XIV, and XV which compare whole task training on RT1, PMT and MT, with pivot sub-task training on similar measures. In all cases the  $F$  scores are not significant. These findings are supported by several researchers (e.g., 13, 21, 22) who found whole task practice as beneficial



as sub-task practice but not significantly better. Table XXVI does not support the  $H_{01}$ : whole complex task = pivot sub-task training. It shows that the control group has significantly better chest pass times at trial intervals 1-5, 11-15, and 16-20. Significance at these intervals may be explained in that the pivot sub-task group was just beginning to integrate the chest pass component of the whole task while the control group had 50 previous training trials on the chest pass and pivot sub-task as parts of the whole. Figures 12, 13 and 14 illustrate the apparent difficulty the pivot sub-task group had in integrating the previously unpracticed component into the whole task training. This interference effect was found by several writers (13, 106, 68). Evaluation of MT2 (see table XXXII) indicates that the control group was significantly better at trial levels 1-5/51-55. This difference may be related to error performance as indicated by tables XXXIV. At trial levels 1-5/51-75 the pivot sub-task group had committed 41 errors as compared to 21 by the control group. Results related to MT2 indicate that significant differences in performance by the control group in CP-W are attenuated by slight but not significant performances of the pivot sub-task group on RT1, PMT, and MT1 measures.

In summary the null hypothesis  $H_{01}$  is rejected in 2 out of 5 time measures at 4 trial levels.

$H_{02}$ : Training on the whole task = part training on pass sub-task.

The null hypothesis was rejected when RT1 was examined (see Table IX). At trial level 21-25/71-75 the control group was significantly better.  $H_{02}$  was rejected for the PMT measures. The control group was significantly better over a space of ten trials. Table XX verified rejection of  $H_{02}$  for MT1 scores. The control group was significantly better at all



compared trial levels.

Table XXVII shows the interfering effects of the addition of the sub-task pivot component on CP-W. The control group has significantly superior time scores at trial levels 1-5, and 11-20. Cumulative time scores for the pass group rise to levels previously attained in the early stages of sub-task practice. Other researchers (13, 48, 68, 106) found interfering effects similar to those revealed in this study.

Table XXXIII compared the whole task and pass-sub-task on the MT2 measure. The control group was significantly better at all trial levels. The interfering effects of attempting to combine the pivot sub-task movement with previously practiced pass sub-task seems quite evident.

In summary the null hypothesis is rejected for all 5 time measures.

$H_{o_3}$ : Training on pivot sub-task = training on pass sub-task.

The null hypothesis  $H_{o_3}$  is rejected when RT1 scores are compared. The pivot group (see Table VI) was significantly superior at trial level 1-5. The pass sub-task group took five trials to bring RT1 scores down to a comparable level with the pivot sub-task group who had 50 previous trials involving RT1 as part of the pivot sub-task training.

Analysis of PMT measures (see Table XII) revealed that the pivot sub-task group had better PMT mean times over 50 trials of whole-task training and these scores significantly favor the pivot sub-task group at trial levels 1-10, 16-20, and 36-40. Figure 17 gave indication that the pivot sub-task learning curve for PMT may have reached its asymptote. This possibility is supported by the PMT transfer score (see Table X) which shows that 98% of the total possible learning of the pivot sub-task group had been accomplished during sub-task training.

The null hypotheses  $H_{o_3}$  was rejected for the MT1 measure (see Table



XVIII). The pivot sub-task group was significantly superior over 50 trials of whole task training. This finding lends support to the concept that sub-tasks of a complex perceptual-motor task do not contribute equally to whole task learning. The factors creating inequality of contribution to whole task learning could not be isolated in the study but sub-task complexity and the relatedness of the sub-task training to the whole are suggested causes. Several authors (6,8,15,19,56,65,84,88,99) found task complexity and specificity of sub-task training to whole as factors influencing transfer effect.

Comparisons of CP-W scores showed that the hypotheses  $Ho_3$  was rejected for this measure. The pivot sub-task group (see Table XXIV) was found to be significantly better at trial level 6-10. The observation indicates that the pass sub-task group had difficulty integrating the previously practiced sub-task of passing into the whole-task routine. The pivot sub-task pivot group had better chest pass time scores throughout 50 trials of training although significance is observed at only one trial level 6-10. The results of this comparison indicate the possible dangers of learning sub-tasks. Sometimes sub-task practice may have an interfering or negative effect on whole task training.

Results of MT2 scores are compared in Table XXX. The pivot sub-task group performed significantly better than the sub-task pass group at all trial levels throughout whole-task training. The absolute rejection of  $Ho_3$  poses an interesting question for the teacher. What sub-tasks of a complex skill should be taught and which should not? How does the teacher identify the method of skill presentation?

$Ho_4$ : Whole Task training = pass sub-task = pivot sub-task training.  
null hypotheses  $Ho_4$  is postulated to examine whether transfer effects were



present and in what direction (positive, negative, or zero effects).

Table V demonstrates that a positive transfer effect influenced RTI scores of the pivot sub-task group. Pivot sub-task group was significantly better than the control over trials 1-25. This effect is not evident at trial intervals 26-50. The result is consistent with other researchers (52,45,33) who found that the transfer effect dissipated as the learner approached the limits of learning for the particular motor skill being studied. Table VI showed a significant positive transfer effect in favor of the pivot sub-task group at trial interval 1-5. The pass sub-task group was significantly superior to the control group (see Table VII) at trial interval 6-10. This result indicated a positive transfer effect for the sub-task training of the pass group.  $H_{04}$  for RTI was rejected and points to the variability of transfer effect as a result of sub-task training. It seems evident that it was worthwhile to have some sub-task training in pivoting and a waste of time to practice chest passing as a sub-task of the whole.

Tables XI, XII and XIII display PMT measures. Table XI showed the pivot sub-task group was significantly superior over the control for PMT measures indicating the presence of positive transfer effects; Table XII illustrated transfer effect inequality of sub-tasks to the whole; and Table XIII illustrated a zero transfer effect. The pass sub-task group did not have significantly higher PMT scores than the control group creating what has been classified as a zero transfer effect. Learning to chest pass did not facilitate the pass sub-task's ability to learn the pivoting sub-task easier than the control group.

MTI was a measure of total time required for the pivot sub-task. Comparison of pivot sub-task and control groups in Table XVII showed the



sub-task pivot group to be significantly superior at all trial levels 1-50. This result illustrates a strong positive transfer effect that continues to influence training throughout all trial intervals 1-50. These results reject the null hypothesis  $H_{0_4}$ .

Table XVIII demonstrated that the pivot sub-task training was more beneficial than pass sub-task training.

Table XIX gives some indication that sub-task training on one part may have facilitated acquisition of another sub-task. The pass sub-task group had a significantly superior MT1 performance over the control group at trial level 1-5 without having previously practiced the pivot sub-task. These effects were not evident in subsequent blocks of trials although performance times of the pass group are lower at trial levels 1-36.

Comparison of CP-W (see Tables XXIII, XXIV, and XXV) permitted some interesting observations. The pivot sub-task group (see Table XXIII) had significant better performance times than the control at trial levels 1-15, 26-30, and 45-50. Although the pivot sub-task group had not practiced the chest pass as a sub-task they performed better than the control group in 30 trials out of 50. Learning the pivot sub-task seemed to facilitate acquisition of the chest pass sub-task.

The pivot sub-task was significantly better than the chest pass sub-task group on trials 6-10 (see Table XXIV). Mean time scores for the pivot sub-task group were better at all trial levels over the pass sub-task group except at trial 36-40 where the pass sub-task group was slightly better (1/1,000 of a second). It seemed from observation of Table XXIV that the pass sub-task group suffered proactive interference from the effects of trying to learn the pivot sub-task.

The pass sub-task group was superior to the control group in trials



1-5 (see Table XXV) indicating a positive transfer effect for the CP-W measure. Significant differences were not noted in subsequent trial intervals. The observation was that the advantage gained through pass sub-task training had dissipated after 5 trials.

A comparison of MT2 clearly indicated that  $H_{04}$  was not tenable. The pivot group was significantly superior to the control at all trial levels 1-50 indicating the effects of positive transfer (see Table XXIX). The pivot sub-task group was also significantly superior at all trial levels over the pass sub-task group (see Table XXX). The observation supports the view held by Gagne and Foster (52) that sub-tasks vary in the degree that each facilitate the acquisition of the whole task. Table XXXI showed the pass sub-task group to be significantly superior to the control in trials 1-10. This result showed that pass sub-task training was beneficial but that the positive effects were short-lived. The value of chest pass sub-task training could be questioned in terms of learning economy.

In summary, the null hypothesis that whole task = pass sub-task = pivot sub-task, was rejected in all comparisons. Transfer effect was evident and varied from a strong positive effect accrued from pivot sub-task training, to zero effects from pass sub-task training.



## CHAPTER V

### SUMMARY AND CONCLUSIONS

The purpose of this study was to investigate whether practice on sub-tasks of a complex perceptual-motor task were beneficial. In addition, the economy of learning sub-tasks was compared to whole task training. The sub-tasks of pivot and chest pass were compared to determine if both contributed equally to learning of the whole task.

The complex perceptual-motor task in the study was a one hundred and eighty pivot right or left followed by the chest passing of a basketball through one of two basketball hoops situated vertically to the right and left of the subject. Two sub-tasks were identified for purposes of study. One was a pivoting movement right or left and the other was a chest passing movement.

Ninety boys from five elementary schools participated in the study. They were randomly assigned to groups and tasks. Three groups (N=30) were formed. Two experimental groups performed either the pivot sub-task or the chest pass sub-task before practice on the whole. The third group was designated as control and only trained on the whole task. The experimental sub-task pivot group had 50 trials of pivot training followed by 50 trials of whole task training. The experimental sub-task pass group had 50 trials of chest pass training followed by 50 trials of whole task training. The control group had 75 trials of whole task training. Electronic time measures and subjective error scores were obtained for each subject.



Both experimental groups benefited from sub-task training. The accrued benefits varied according to the type of sub-task training. Sub-task training benefits were affected during whole task training by the interfering effects of integrating unlearned parts.

In terms of economy the most efficient method of learning was by whole task training without including preliminary practice on a subordinate skill.

The following conclusions appear to be justified within the limitations of the experiment.

1. Pivot sub-task training facilitated acquisition of the whole complex perceptual-motor task.
2. Pass sub-task training facilitated acquisition of the whole complex perceptual-motor task.
3. Whole task training was significantly the most economical method of learning the complex perceptual-motor task.
4. Training on the pivot sub-task was significantly more beneficial than training on the pass sub-task.
5. Learning the whole complex perceptual-motor task for all three groups was related to errors.
6. Learning plateaus occurred during sub-task and whole task training.
7. Experimental groups experienced significant interfering effects from sub-task training while training on the whole complex perceptual-motor task.
8. Conditions of positive and zero transfer effect were noted.

The results of the study have important implications for motor skill teaching in physical education. It is not uncommon to see many motor skills being taught using part-whole methods. For example, pivoting



and passing should be taught as a unified whole. How many motor skills are being taught using part-whole methods? The study suggests that part-method motor skill teaching presentation should be carefully evaluated.

Further research on part-whole transfer of gross motor skills is required. Research should focus on determining when it is more economical; in terms of reduced errors, fewer practice trials, or better performance, to learn parts then the whole, as opposed to whole task training. Multi-dimensional studies should be developed which could evaluate a number of sub-task skills with varying amounts of part practice.



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APPENDIX A  
STATISTICAL TREATMENT



The formula employed to express transfer was as follows:

Percent Transfer =

$$\frac{C \text{ Group Score} - T \text{ Group Score}}{C \text{ Group Score} - \text{Total Possible Score}} \times 100$$

(51:97)

The denominator of this fraction (53:47) expresses the range of scores possible in learning, whereas the numerator represents the conventional method of arriving at a value of the amount of transfer.

The estimate of final learning was taken as the best time for five trials on the whole task regardless of which group achieved this measure.

The percentage value obtained was a method of expressing how much training on the sub-tasks had contributed to total possible learning.



APPENDIX B  
SAMPLE DATA SHEETS  
FORM LETTERS



June 18, 1965  
University of Alberta

Dear Parent,

I am conducting a part-whole transfer-of-training study at the University of Alberta. I would like to use your son as one of my subjects.

I wish to explore the question: "Will learning the parts of a complex skill facilitate the acquisition of the whole or is there positive transfer from the parts of a skill to the whole?" In order to test this question I have modified two basketball skills into what I term a complex task. This complex (whole) task is to pivot, then chest pass.

My experimental design calls for ninety ten year old boys, divided into three groups, two experimental and one control. The experimental groups will learn parts of the task then the whole. The control group will learn the whole without any previous training on the parts. One experimental group will learn how to pivot, which is part of the whole, then learn how to pivot and chest pass as a combined movement, which is the whole task. The second experimental group will learn how to chest pass, which is part of the whole, then after a rest, learn the whole task. The control group, as was mentioned earlier, will learn the whole task without any previous training on the parts.

Statistical procedure will be used to determine the transfer effect of learning parts of the complex task before the whole. Experimental groups will be compared with the control group. From a general educational viewpoint, it is hoped that the results will cast some light on the effect of teaching sub-routines in school physical education programs.

What does the study involve for each subject? Each subject will be involved in ONE testing period lasting approximately 90 minutes, sometime during the month of July. It is hoped that each subject's testing date



can be scheduled to suit the summer plans of the parent.

The study, which will be something of a game for the children, will be conducted in the Fitness Research Unit located in the basement of the new Education Building. Subject should enter the Education Building through the WEST entrance and follow the signs to the correct room. The posted signs will read: "BOYS - 10 YEARS - THIS WAY".

Each boy should wear running shoes and a T-shirt. Either short or long pants is acceptable.

I will contact the parent of each subject by telephone to check and finalize testing date and other pertinent details.

I can be contacted at home or at the university.

HOME: Mr. Rex Beach  
9423 - 66 Ave.  
439-6252

UNIVERSITY: Mr. Rex Beach  
Education Building  
439-8721 Extension 837

Thanks so much for your cooperation.

Sincerely,

Rex H. Beach



# Edmonton Public School Board

10733 - 101 STREET  
EDMONTON, ALBERTA

June 18, 1965.

Mr. R. H. Beach,  
9423 - 66 Avenue,  
Edmonton, Alberta.

Dear Mr. Beach:

Permission is granted for you to proceed with your research project.

By telephone the principals of McKernan, Garneau, Windsor Park and Strathcona Schools were notified that you would be in touch with them.

I trust you will secure the co-operation of the principals and that your work will be successful.

Yours sincerely,

T. D. Baker,  
Associate Superintendent - Instruction.

TDB:dk



# SUBJECT DATA SHEET

NAME:

SCHOOL:

ADDRESS:

PHONE:

BIRTHDATE:

TESTING DATE:

TESTING TIME:

ASSIGNED GROUP:

EXPERIMENTAL

CONTROL

ASSIGNED TASK:

PIVOT SUB-TASK

PASS SUB-TASK

WHOLE TASK

PERFORMANCE DETAILS:

## SUBJECTIVE ERROR TALLY SHEET

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

TIME: \_\_\_\_\_

GROUP: (Circle One) - Pivot Sub-Task  
Pass Sub-Task  
Control

Trial	Pivot Wrong Way	Hit Hoop Rim	Wrong Hoop	Incorrect Pass
1				
2				
↓				
50				
Totals				



# TIME SCORE COLLECTION SHEET

SUBJECT: \_\_\_\_\_

TIME: \_\_\_\_\_

DATE: \_\_\_\_\_

TASK: \_\_\_\_\_ GROUP: \_\_\_\_\_

	*	**	***		****	**	***
Trial				Trial			
1				51			
to				to			
50				100			

\*Scores for RT1-Reaction Time and CP-P-Chest Pass Time for Sub-Task Pass were collected in this column

\*\*Scores for MT1-Movement Time One were collected in this column

\*\*\*Scores for MT2-Movement Time Two were collected in this column

\*\*\*\*Scores for RT1-Reaction Time were collected in this column



APPENDIX C  
APPARATUS DETAIL



## CONSTRUCTION OF RUBBER CONTACT MATS

- STEP 1 Take one corrugated rubber mat; lie it flat with the ribbed side to the outside.
- STEP 2 Take a section of wire mesh (copper or steel window screen may be used) and place it on top of the mat. Around one edge of the screen weave in a copper wire lead.
- STEP 3 Place a rubber border about 3/4 inch wide on top of the screen and around the edge (same material as the mats is recommended). Glue the strip through the screen to the underlying mat.
- STEP 4 Place a rubber sponge disc (1/2 inch in diameter) every four inches on the screen. Distance between disc will depend upon size and stiffness of the rubber mats.
- STEP 5 Place another rubber mat with a copper screen attached to the inner side on top of the rubber discs. Weave a copper wire lead along one edge of the top screen at 90° to the copper wire lead of the lower screen.
- STEP 6 Glue the edges together to complete construction of the mat.

Contact mats constructed in the manner described require very little maintenance. Proper placement of the sponge discs insures contact between the two screens no matter where an individual places his foot.



DIRECTION OF SUB-TASK  
MOVEMENT FOR EACH TRIAL

Trial	Pivot/Pass Direction	Trial	Pivot/Pass Direction
1	Right	26	Left
2	Left	27	Right
3	Right	28	Right
4	Right	29	Right
5	Right	30	Right
6	Right	31	Right
7	Right	32	Right
8	Right	33	Left
9	Right	34	Left
10	Right	35	Left
11	Left	36	Left
12	Right	37	Right
13	Left	38	Left
14	Left	39	Left
15	Right	40	Left
16	Left	41	Left
17	Left	42	Left
18	Right	43	Right
19	Left	44	Left
20	Left	45	Left
21	Right	46	Right
22	Left	47	Left
23	Left	48	Left
24	Left	49	Right
25	Right	50	Left

NOTE: Direction for each trial was determined by coin toss: heads right, tails left.

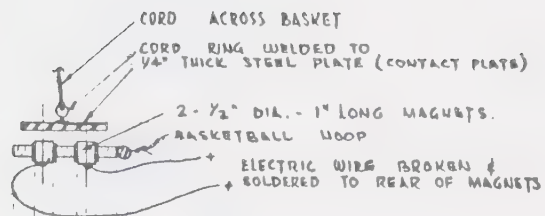
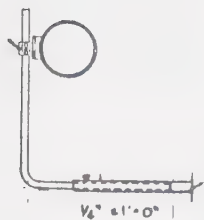


# DIRECTION OF WHOLE TASK MOVEMENTS FOR EACH TRIAL

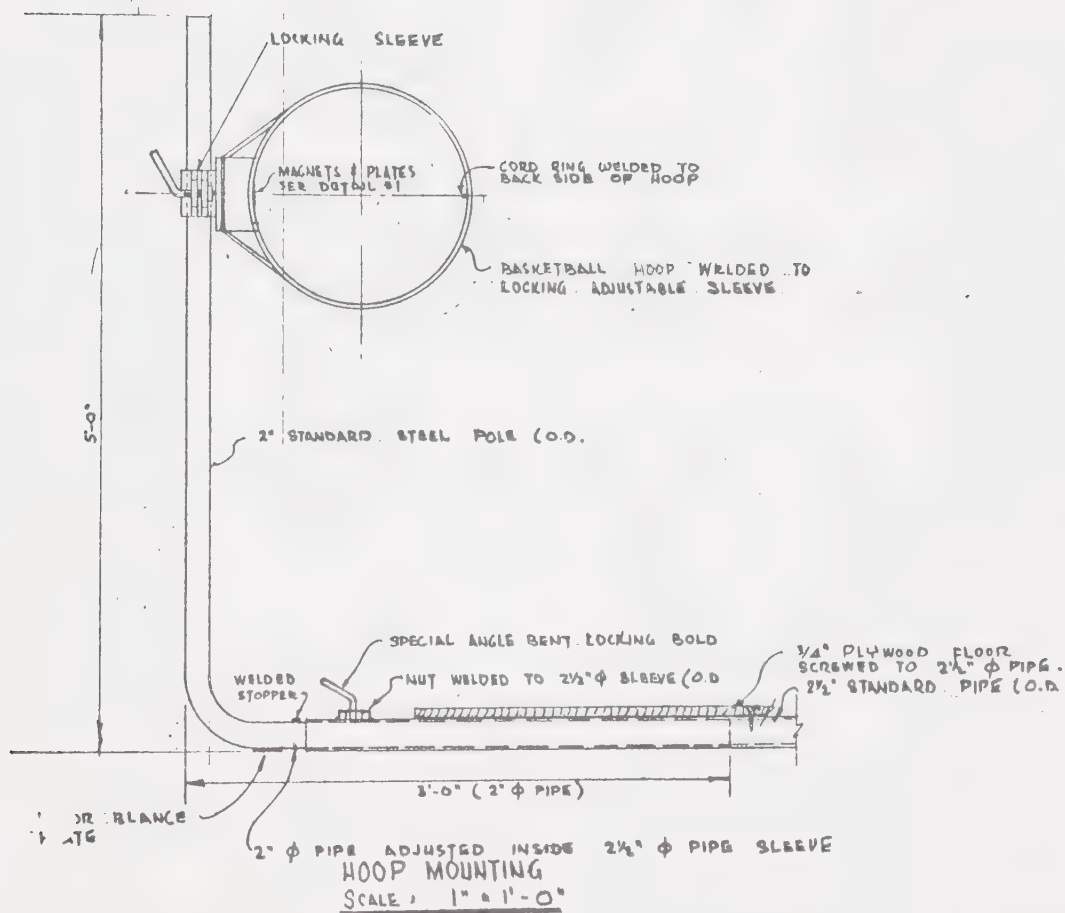
Trial	Pivot Direction	Pass Direction	Trial	Pivot Direction	Pass Direction
1	Right	Right	39	Left	Right
2	Left	Right	40	Left	Left
3	Left	Right	41	Right	Left
4	Left	Left	42	Left	Left
5	Left	Right	43	Left	Left
6	Left	Right	44	Right	Left
7	Left	Right	45	Left	Left
8	Left	Right	46	Left	Right
9	Left	Right	47	Right	Right
10	Right	Left	48	Left	Left
11	Right	Right	49	Left	Left
12	Left	Left	50	Left	Left
13	Left	Right	51	Right	Left
14	Left	Right	52	Left	Left
15	Right	Left	53	Left	Right
16	Left	Left	54	Right	Left
17	Left	Right	55	Right	Left
18	Right	Right	56	Right	Right
19	Right	Left	57	Right	Left
20	Left	Right	58	Left	Right
21	Right	Left	59	Right	Right
22	Right	Left	60	Right	Right
23	Left	Right	61	Left	Right
24	Left	Right	62	Left	Left
25	Right	Right	63	Left	Left
26	Left	Right	64	Left	Right
27	Right	Right	65	Right	Left
28	Right	Right	66	Right	Left
29	Left	Left	67	Right	Left
30	Left	Right	68	Left	Right
31	Right	Right	69	Left	Left
32	Left	Right	70	Left	Right
33	Left	Right	71	Left	Left
34	Right	Right	72	Left	Right
35	Left	Right	73	Left	Left
36	Right	Right	74	Right	Right
37	Left	Left	75	Left	Right
38	Left	Left			

NOTE: Direction for each trial was determined by tossing two coins. For each coin - heads right, tails left.



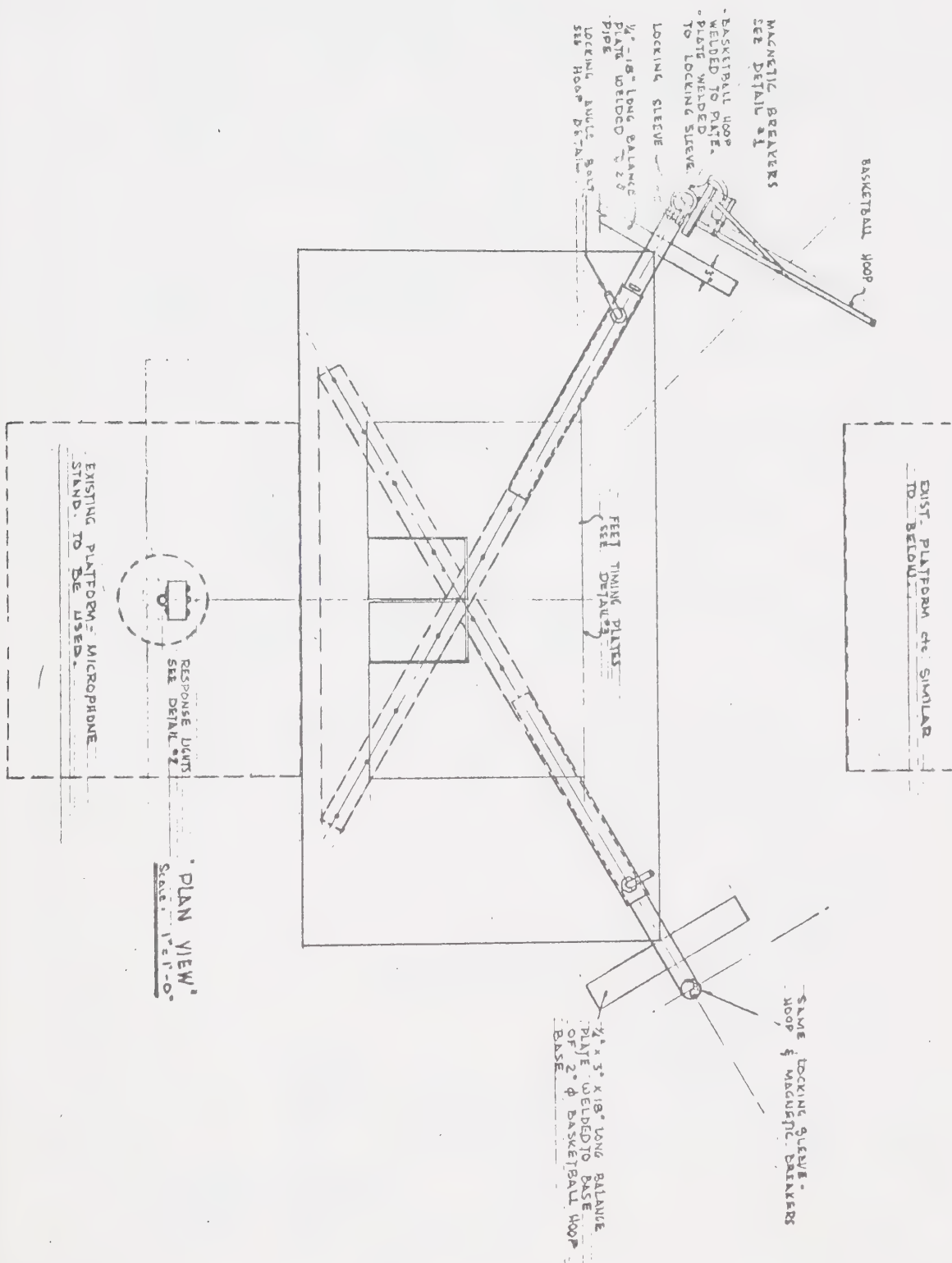


**'BASKET MAGNETIC TIMING BREAKER'**  
DETAIL N-1  
 U.T. 3.



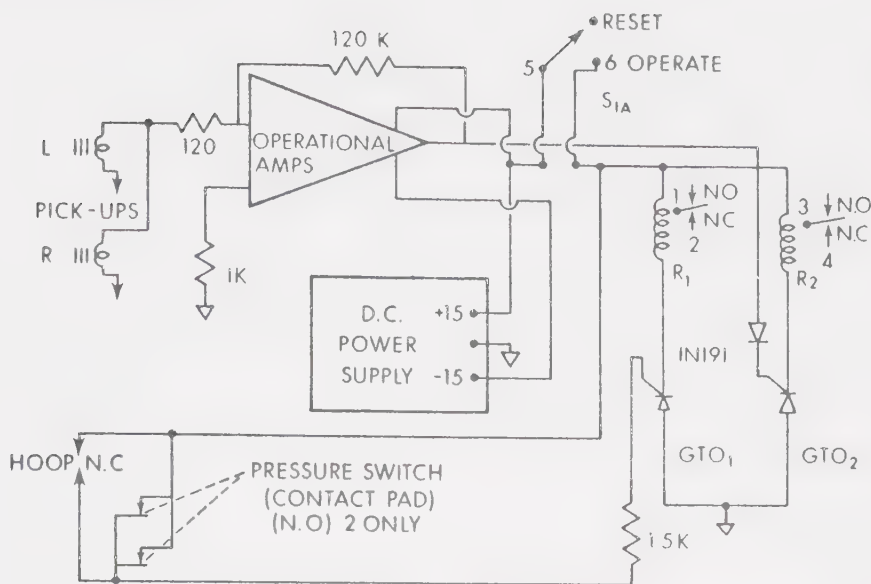
APPARATUS PLAN - SIDE VIEW



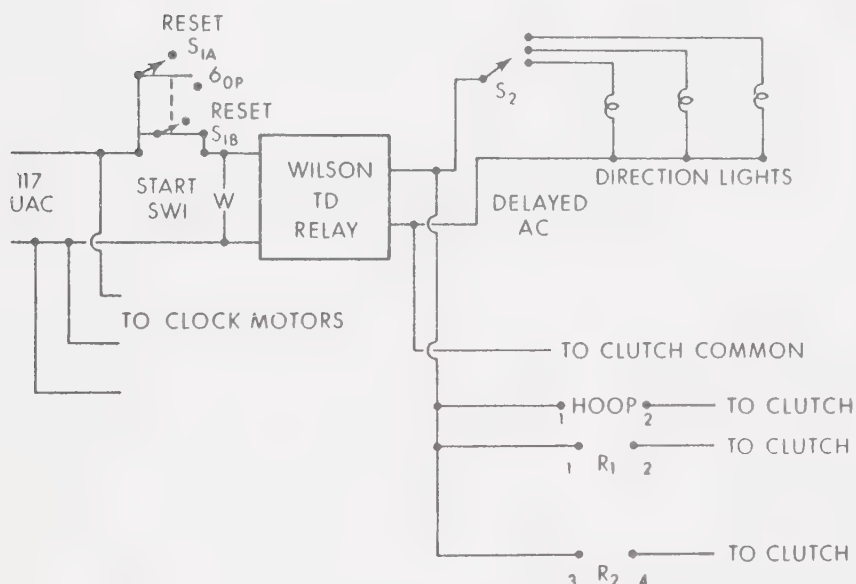


APPARATUS PLAN - TOP VIEW

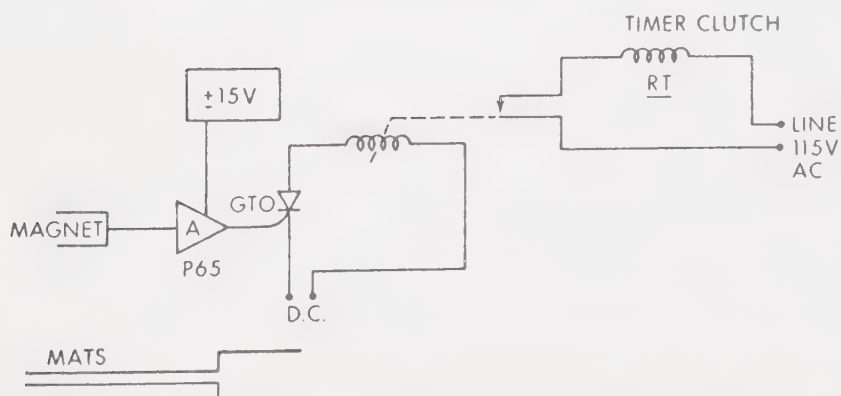




### REACTION TIME AND MOVEMENT TIME CIRCUITS



### CONTROL CIRCUITS



### REACTION TIME AND CONTACT MAT CIRCUIT DETAIL



APPENDIX D  
INSTRUCTIONS TO SUBJECTS



## INSTRUCTIONS TO SUBJECTS FOR WHOLE TASK TRAINING

Control Panel Orientation. "This is the control panel where I will sit. These clocks sweep around once every second (switch lights on). These clocks and the switches here are something like a space ship. They will turn on the "action" lights and tell me how well you played the game."

Pivot Sub-Task Stimulus Lights. "This is a set of "action" lights. The amber light is a warning light and will tell you to be alert. (point to it) because very soon, one of the action lights will go on. This is the left "action" light. This is the "right" action light." (point to each in turn) (Switch the lights on and off).

Training Platform Orientation. "This is a special platform for you to play our pivot-pass game on. These are special rubber mats, which when stepped upon, stop one of the clocks. This line (point to it) is your starting line. You must toe up to this line to start the game. These two rectangular boxes (point to them) are special electrical boxes which will send an impulse to one of the clocks and stop it when the magnets on your toes interfere with the electrical circuit within. Here are the magnets; let's tape them to your running shoes."

Chest Pass Apparatus Orientation. "This is the left hoop and net." If the left action light goes on you will be passing the ball through this hoop (point to left hoop). If the right action light goes on you will be chest passing the ball through this hoop (point to right hoop). These red pennants across the hoops have little magnetic switches on them. When you pass the ball through the hoop, the contacts will be broken and you will stop a clock which will tell me how fast you passed the ball."

Demonstration and Explanation of Game. "The little game you are about to play is done like this -- (Demonstrate - right, then left)."



"Now what do we have to do to play this pivot-pass game? When the warning light goes on, you know that you will have to pivot very soon - be alert with your knees slightly bent and your ball in ready position. Do not move now until one of the action lights comes on. If the left "action" light goes on, take the weight on your left foot and turn yourself around, so that you come to face in the opposite direction. Keep your weight low. If the right "action" light goes on, take the weight on your right and turn yourself around, so that you come to face in the opposite direction. Keep your weight low. As you turn or pivot - keep the foot you turn on fixed or planted in one place until you finish."

As you finish your pivot you will be faced with the second set of action lights. These "action" lights tell you where to chest pass. As you finish, I want you to hold the basketball up and in front of you with your hands holding the ball like this. Fingers spread and thumbs behind the ball. The left or right action light will be on. If the left action light is on, draw the ball towards your chest, then push it with BOTH hands toward the correct basket. I repeat - push it with BOTH hands toward the correct basket."

"Are there any questions?" (After answering any questions, the subject is then given a basketball and asked to assume a position on the starting line with the command) - "Toe-up to the line."

"Now, will you repeat those instructions for me?" (Subject repeated instructions)

"Now, let's practice this ... once to the left and once to the right." (The subject took a practice trial of the whole task to the left, then to the right)

"Now we are ready to play the game. The idea of the game is to see



if you can respond to the lights correctly, pivot and pass as quickly as you can with as few errors as possible. I will tell you if you make an error.

The subject was then taken through 50 training trials, 10 minutes of interpolated rest, then 25 more training trials.



## INSTRUCTIONS TO SUBJECTS FOR SUB-TASK PASS TRAINING

Control Panel Orientation. "This is the control panel where I will sit. These clocks sweep around once every second (switch clocks on). These clocks and the switches here are something like a space ship. They will turn on the "action" lights and tell me how well you have played the game."

Chest Sub-Task Stimulus Lights. "This is a set of "action" lights. The red light is a warning light and will tell you to be alert (point to it) because very soon, one of the "action" lights will go on. This is the left "action" light. This is the right "action" light." (Point to each in turn. Switch the lights on and off).

Training Platform Orientation. "This is a special platform for you to play the game on. This line here, (point to it) tells you where to place your heels."

Chest Pass Apparatus Orientation. "This is the left hoop and net. If the left "action" light goes on you will be passing the ball through this hoop (Point to left hoop). If the right "action" light goes on you will be chest passing the ball through this hoop (Point to right hoop). These red pennants across the hoops have little magnetic switches on them. When you pass the ball through the hoop, this contact will be broken and you will stop a clock which will tell me how fast you passed the ball.

Demonstration and Explanation of Game. "The little game you are about to play is done like this -- (Demonstrate with the left "action" light on).

"Now what do you have to do to do this correctly? First, assume a starting position with your heels along this line. Bend your knees, hold your basketball up in front of you with your hands holding the ball like



## INSTRUCTIONS TO SUBJECTS FOR SUB-TASK PIVOT TRAINING

Control Panel Orientation. "This is the control panel where I will sit. These clocks sweep around once every second. (Switch clocks on). These clocks and the switches here are something like a space ship. They will turn on the "action" lights and tell me how well you have played the game."

Pivot Sub-Task Stimulus Lights. This is a set of "action" lights. The amber light is a warning light and will tell you to be alert because very soon, one of the action lights will go on. This is the left "action" light. This is the right "action" light (point to each in turn). (Switch lights on and off.)

Training Platform Orientation. "This is a special platform for you to play our pivot-pass game on. These are special rubber mats, which when stepped upon, stop one of the clocks. This line (point to it) is your starting line. You must toe up to this line to start the game. These two rectangular boxes (point to them) are special electrical boxes which will send an impulse to one of the clocks and stop it when the magnets on your toes interfere with the electrical circuit within. Here are the magnets; let's tape them to your running shoes."

Demonstration and Explanation of Game. "The little game you are about to play is done like this -- (Demonstrate - right, then left)."

"Now what do you have to do to play this game? When the warning light goes on, you know you will have to pivot very soon - be alert with your knees slightly bent and your ball in ready position. Do not move now until one of the "action" lights comes on. If the left "action" light goes on, take the weight on your left and turn yourself around so that you come to face in the opposite direction. Keep your weight low. If the right "action" light goes on, take the weight on your right and turn yourself



around so that you come to face in the opposite direction. Keep your weight low. As you turn or pivot - keep the foot you turn on fixed or planted in one place until you finish."

"Are there any questions?" (After answering any questions, the subject is then given a basketball and asked to assume a position on the starting line with the command) - "Toe-up to the line."

"Now, will you repeat those instructions for me? (Subject repeated instructions).

"Now, let's practice this ... once to the left and once to the right." (The subject was then given a practice trial to the left then one to the right.

Now we are ready to play the game. The idea of the game is to see if you can respond to the lights correctly, pivot as quickly as you can with as few errors as possible. I will tell you if you make an error.

The subject was then taken through 50 training trials on the pivot sub-task, followed by 10 minutes of interpolated rest.

After the rest period the following instructions were given -- "Now we are going to add something to our game (uncover the hoops) and make it a pivot-pass game."

Orientate subject to chest pass apparatus and give instructions for whole task training (See instructions for whole task training for detail).

The subject does 50 trials of whole task training.



this (demonstrate). Fingers spread and thumbs behind the ball. After the warning light, either the left or right action light will go on. If the left action light goes on, draw the ball towards your chest, then push it with BOTH hands toward the correct basket. I repeat - push it with BOTH hands toward the correct basket."

"Are there any questions?" (After answering any questions, the subject is then given a basketball and asked to assume a position on the starting line with the command) - "Heel-up to the line."

"Now, will you repeat those instructions for me?" (Subject repeated instructions).

"Now, let's practice this ... once to the left and once to the right." (The subject was then given a practice trial to the left, then one to the right.

"Now we are ready to play the game. We will play this passing game for awhile then take a break and add something else to it. The idea of the game is to see if you can respond to the lights correctly, pass as quickly as you can with as few errors as possible. I will tell you if you make an error."

The subject was then taken through 50 training trials on the pass sub-task, followed by 10 minutes of interpolated rest.

After the rest period the following instructions were given -- "Now we are going to add something to our game (uncover pivot stimulus lights) and make it a pivot-pass game."

Orientate subject to pivot apparatus and give instruction for whole task training (See instructions for whole task training for detail).

The subject does 50 trials of whole task training.

















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